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ABSTRACT

The total cost of ownership (TCO) of computer technology in California's K-12 public schools is assessed via a study of two high schools, one elementary school, and one school district that have implemented successful technology programs. The research covers four fundamental problems in technology ownership that add costs to schools and create problems for educators: (1) lack of technical expertise; (2) lack of sustained funding; (3) lack of incentive to manage technology efficiently; and (4) difficulties in managing technology programs. Three State policies are recommended to help schools and school districts identify, plan, and manage TCO for technology. The first requires schools to have separate budget accounts for technology in the school budget. The second divides State funding into four phases with each contingent on a school's readiness to proceed to the next phase. The third creates incentives for school districts to provide technology support more efficiently. Appendices provide the best practices for each phase of the life cycle of owning and managing technology, and descriptions and overviews of each of the study's schools and the school district. (Contains 24 references.) (GR)

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Managing Technology Efficiently in California K-12 Schools:

Policies & Practices for Minimizing the Total Cost of Ownership (TCO)

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Executive Summary

"[T]he possibilities of using [a computer] poorly so outweigh the chance of using it well, it makes people like us, who are fundamentally optimistic about computers, very reticent." – Sherry Turkle[1] (Oppenheimer 1997).

California is determined to integrate technology into schools; however, simply placing computers in schools will not improve student achievement or learning. Implementing a technology program, one that incorporates technology into the curriculum, creates problems for schools because owning technology is expensive. The cost of technology is not simply the purchasing price; it consists of a variety of costs that accumulate over the technology's "life." The total cost of ownership (TCO) for technology is the life cycle of costs for technology. These include: capital costs (hardware, software, and facilities), administrative and operating costs (planning, upgrade, replacement, and technical support), and end user operation costs (staff development and user downtime).

Our paper assesses TCO for technology in K-12 schools. We studied two high schools, one elementary school, and one school district that have implemented successful technology programs. Our research uncovered four fundamental problems associated with K-12 schools owning technology: 1) lack of technical expertise; 2) lack of sustained funding; 3) lack of incentive to manage technology efficiently; 4) difficulties in managing technology programs. These problems manifest themselves in costs to schools and create stumbling blocks for educators.

By identifying, planning, and managing TCO for technology, schools and school districts can maximize their investment in technology programs. We recommend three state policies to help schools and school districts do this. The first recommendation requires that schools have separate budget accounts for technology in the school budget. The second divides state funding into four phases; each phase is contingent on a school's readiness to proceed to the next phase. The third recommendation creates incentives for

[1] Professor of the Sociology of Science, Massachuetts Institute of Technology

school districts to provide technology support more efficiently. Our recommendations are grounded in three principles:

- They supplement existing policies.
- They do not cause financial burdens to either the State or schools.
- They encourage schools to adopt "best practices" during the planning, implementation, and management of technology programs.

We feel that these recommendations, if crafted into state policies, would help schools plan TCO for technology and develop successful technology programs.

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Introduction

An inner city elementary school in San Francisco has 106 networked PCs for the school's 440 students. The school has one computer lab for class exercises and four PCs in each classroom, all connected to the Internet and equipped with headphones so students can focus on independent activities. The school has developed two ways to use this technology through a partnership with employees of Miller Freeman, Inc., a San Francisco publishing company. In an electronic version of pen pals, students and Miller Freeman mentors correspond via e-mail, providing a stimulating context for teaching grammar and syntax. Miller Freeman also helps students at the school produce school newspapers. Teachers send student writing and digital photos to the company, and the employees turn these words and images into a professional looking newspaper using a publishing program. The newspapers are sent back to the school, downloaded by teachers, and sent home with students. These uses of computer technology embody the rosy side of technology: technology as a tool to provide individualized learning and to connect schoolwork to the workplace and the home.

Our paper focuses on the not-so-rosy side of technology: costs incurred over the lifecycle of technology. Any person who owns a computer knows that a computer costs more than the price tags on the monitor, printer, and computer. There is software, virus protection, Internet access, visits by a repairperson, and more. For schools, these costs are substantial:

- Plan and implement a computer network (form committees after school, identify common needs, determine specifications, haggle with contractors, etc.).
- Train teachers how to use the technology and integrate it into the curriculum.
- Address all problems that arise on a day-to-day basis ("how to" questions, jammed printers, malfunctioning hardware, etc.).

Business analysts define the sum of explicit and implicit costs of technology as the total cost of ownership (TCO). TCO includes a life cycle of costs incurred by owning technology, from the initial purchase to the discard of the computer. As a general rule,

the annual TCO of a networked PC adds at least 100% to the purchase price for the hardware and software.[2] In this paper, we examine TCO for technology in schools.

TCO for school technology is important because political and non-political forces are determined to put computers in schools. The Clinton administration has been a leading proponent of using technology in education. For example, it helped condition the deregulation of the local telephone business on the creation of a $2.25 billion / year fund to subsidize Internet access and wiring for schools (Borland, 1998). The administration is also proposing $800 million in educational technology grants / initiatives in FY 2000, and will provide additional funding through the Telecommunications and Information Infrastructure Administration, National Science Foundation, and school block grants (President's proposed budget and Rosenthal, 1998). California has made educational technology a priority as well. The Digital High School Grant (DHS Grant) started in 1997 and will award $151 million in grants this year to schools demonstrating an eagerness and ability to use technology in education (Keegan, 1999). In addition, Assembly Member Mazzoni has proposed a bill to fund school facilities modernization, including technology infrastructure (California AB 695). On the Senate side, Senator Figueroa is sponsoring a bill to extend the DHS Grant down to junior high schools (California SB 20). Finally, numerous non-profits, firms, and educational reform groups are supporting and sponsoring educational technology initiatives. Public and private sources for educational technology are projected to total $30 billion nationwide (Carter, 1998).

Our paper does not question whether society should make such a large investment in educational technology. Rather, given that schools are investing in technology, we ask the question: what, if anything, can California do to help schools plan, budget, and manage technology efficiently? Clearly, enough dollars are at stake to make this question relevant. Schools must adopt and manage technology efficiently – whether to improve educational outcomes or to ensure a maximum return on the State's investment in educational technology.

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[2] Estimates for the annual TCO for a typical Windows 95 desktop in 1998 ranged from $2,680 (Forrester Group) to $2,859 (Zona Research) to $9,784 (Gartner Group) [Baldwin, 1998].

Unfortunately, the lack of attention given to TCO in schools requires that we begin our research at ground zero. That is, we inquire into what schools are currently doing to adopt and manage technology. We study three schools and one school district that are aggressive adopters of technology:

- An inner city elementary school in San Francisco.
- New Haven Unified School District, Union City.
- Loara High School, Anaheim.
- Broadway Senior High School, San Jose.

The four case studies represent an interesting sample. The inner city elementary school was designated a technology school in a 1984 segregation lawsuit. The New Haven School District runs a sophisticated computer network and has taken a very centralized approach to managing technology. Loara High School recently received a DHS Grant, the primary state-funding source for high school technology. Broadway High School is a "second-chance" school that provides students with a second chance through technology. Appendices 2-5 profile each school and outline the factors important to TCO.

The case study experiences do not represent the experiences of all California schools. However, the anecdotal evidence suggests that many schools face similar problems to those encountered in the case studies. Both government organizations and private enterprises encounter similar management problems with technology. Indeed, many costs of owning technology are inherent in the technology, not contingent on the owner.

While we hesitate to generalize too much from our case studies, we nevertheless address the broad policy question: how can California help schools plan and manage technology? After defining TCO for schools, we analyze different policy options the State might consider to help schools plan and minimize TCO. We feel the current policy focus needs to shift from helping schools get hardware and Internet access to helping schools bear the full cost of owning this technology. The purpose of our paper, stated broadly, is to stimulate discussion of policy options for helping schools manage and use technology. The secondary purpose is to identify specific practices that schools should

consider when investing in technology, compiled as a list of best practices for managing technology (See Appendix 1).

The Problem and How It Has Played Out in Four Cases

Framework for the Problem

In some sense, how schools manage technology should be no different than how businesses manage technology. A school has a CEO in the principal, an administrative staff (teachers), a large number of users (students), and often a good-sized computer network. Why should managing technology be more challenging in schools than private business? Schools, unlike businesses, lack the incentive to manage technology efficiently, lack sustained funding for technology, and lack technical expertise.

Managing technology *is* a problem for private businesses.[3] Rapid change in technology and the distributed aspect of computer networks create inherent management difficulties. In 1965, Intel's co-founder Gordon Moore theorized that microprocessor performance doubles every 18 months. As amazing as this probably sounded in 1965, the industry has turned his theory into reality (Moore's Law). Continuous innovation creates "needs" that did not exist previously; consequently, individuals and organizations continue to add and learn the latest technology. A second management difficulty arises from distributing computer technology to individual users. Personal computers have replaced centralized mainframe systems for most applications. This distributed computing environment has three important ramifications. First, an organization has greater difficulty reaching consensus on computer needs because more users exist and each has separate needs; hence planning is more difficult. Second, every user – not just the mainframe engineer – needs to know how to use the technology properly; hence, training becomes more crucial. Third, controlling the uses of the technology – from enforcing a standard set of applications to assisting individuals who have technical problems – is challenging; hence support is more difficult. The distributed nature of computing and the rapid innovation in computers and networking make even the most technically savvy companies weary of technology management.

The school setting creates additional problems for technology management. First, schools lack a profit incentive to use technology efficiently. Businesses are acutely aware of using technology to the point where cumulative benefit equals cost, but schools are not. The benefit of technology in schools is not enhanced production (that is, profit), but improvement in education. With such a nebulous target, it would seem easy to undershoot or overshoot. Moreover, it is difficult for schools to readily transfer resources to hone in on the "right" level of technology investment. The school principal has to keep many constituents happy: teachers (and their union), parents, students, and the school board. Allocating more resources to technology often means forgoing resources elsewhere, making some subset of stakeholders unhappy. Most principals do not have the same command and control as a CEO.

Given their inability to shift resources freely, schools must look outside traditional sources to fund technology programs (grants, bonds, and private donations). These funding sources are often one-time allocations for hardware and networking infrastructure. Funding for ongoing costs (for example, training or hiring additional staff) is uncommon. As a result, schools are left in a catch-22. They lack the funds to make an investment in technology. If they do not take advantage of one-time funding sources, they miss out on getting computers. But, if they take the funding, they inherit TCO for technology. The bottom line is, many schools can not afford to own technology.

Lack of technical expertise is another problem that impairs schools in technology management. Technical expertise is required to plan, support, and evaluate the program. Many schools lack technical expertise; or, the expertise is unevenly distributed among schools. The lack of expertise is partly due to a generation gap. As younger, more technically savvy teachers and administrators replace their predecessors, the gap will be alleviated somewhat. However, the problem may be more entrenched. Technical expertise demands a premium price, and high-paying technical jobs lure skilled technology workers to the private sector.

In sum, technology management is a challenge. K-12 schools not only lack technical expertise, they do not have an incentive to manage technology efficiently and

[3] A 1998 survey by Integrated Network Services found that 94% of organizations ranked improving cost of

lack sustained funding. Of course, these are all macro-level problems. At every school site, the problems in managing technology range from establishing network connections to pencils jammed into disk drives.

Problems with Managing Educational Technology

The problems associated with introducing technology in the K-12 setting manifest themselves in costs to schools, school districts, and ultimately taxpayers. These costs arise from planning, budgeting, purchasing, supporting, integrating, and discarding technology. The sum of the costs incurred throughout this life cycle is TCO for technology. In this section, we identify the primary processes (or lack thereof) driving TCO in the case studies.

Planning for Technology

Although the costs were not reflected in budgets, all of the case studies encountered significant costs in planning. The New Haven School District spent $100,000 on a comprehensive "needs" assessment and preliminary designs for the district's technology program. This was only a fraction (~3%) of the $30 million the district spent on its technology infrastructure. Most planning costs are less explicit (that is, the additional long hours teachers, administrators, and community members spend during the planning process). It is time-consuming and costly to:

- Develop a common vision.
- Assess proficiency in technology of teachers and staff.
- Identify appropriate technology.
- Develop a project plan.
- Create a long-range budget.
- Design the network and develop detailed specifications for subcontractors.
- Consult with the district technicians and the facilities/planning personnel.
- Remain current with industry trends in hardware, software, and networking.

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ownership for network and systems management as an important objective (INS, 1998).

Funding and budgeting for technology

The processes for funding and budgeting include:

- Seek matching funds for grant programs (DHS Grant).
- Develop and write grant applications.
- Track legislative regulatory developments (E-rate subsidy).
- Record funds received and expenses.
- Analyze historical costs.
- Prepare and review budgets.

Technology purchasing

Informed technology purchasing requires schools to:

- Track industry and technology trends (read trade magazines, attend trade conferences, participate in user groups, and talk to colleagues).
- Track educational software developments.
- Determine the necessary requirements for technology.
- Write Request for Proposals (RFPs).[4]
- Communicate with vendors and the school district regarding discounts, compatibility, and compliance with state-level standards.

Support for Technology

The cost of technical support is one area of owning technology that most educators seem to understand. The lack of reliable technical support can result in significant periods of downtime when computers do not work. The New Haven School District is spending $380,000 this year on technical support salaries alone. There are numerous indirect costs as well. For example, teachers with technical expertise often get burdened with informal technical support responsibilities that conflict with their primary teaching duties. The total cost of technical support reflect how schools:

- Manage inventory.

[4] RFPs are what schools send out to potential suppliers of technology services. They document exactly what schools want in terms of services, and suppliers make a proposal to deliver the services.

- Follow industry trends in hardware, software, and networking that affect the reliability of service.
- Track tools to support technology.
- Schedule repairs / work.
- Resolve "how to" questions.
- Prevent the recurrence of common problems and inquiries.
- Hire, train, and retain skilled technical support staff.
- Ensure that support concerns factor into purchasing decisions.

Technology Integration

The processes involved in integrating technology into school curriculum include:

- Determine the technological proficiency of staff.
- Organize professional development.
- Provide basic computer training.
- Provide training on how to incorporate technology into the classroom.
- Develop a way to assess student use of technology.
- Research ways to use the technology (for example, teachers searching the web and conversing with colleagues)
- Hire substitute teachers during staff training days.
- Evaluate professional development.

Future Costs

We identified two additional factors in TCO that schools overlook: ergonomic concerns and discard of technology.

Ergonomic concerns: Although the New Haven School District funds a position to address ergonomic concerns for staff, none of the schools we looked at have addressed student ergonomic concerns. A recent *New York Times* article flagged this concern, noting that students spend more class time at the keyboard (Gross, 1999). At Broadway High School, students sit on phone books or other discarded equipment from other schools in the district.

Discard of Technology: It is standard practice for discard fees to be built into large government computer service contracts, but none of the schools we looked at had formal plans for discarding old computers. At Loara High School, computers are passed on to a vocational training center or placed in the school's trash bins. Discard costs are likely to increase as computers become more common and less expensive, making them cheaper to replace than to support.

Estimating the Costs of Educational Technology

We were unable to estimate TCO for the case studies because they did not have the data or the time to procure it. We do, however, develop a framework for calculating – at least planning for – TCO for technology in schools.

The framework for calculating TCO is summarized in Tables 1-3. It is adapted from our case studies and the Gartner Group, a consulting firm specializing in estimating TCO (Young, 1998). It also supports the work by the Consortium for Schools Networking.[5]

[5] Work done by 'Taking TCO to the Classroom,' a project of the Consortium for School Networking, under the sponsorship of Intel Corp. and IBM Corp; <www.cosn.org>.

Table 1. Breakdown of capital costs in calculating TCO for educational technology.

Cost categories	Costs
Hardware	CPU's Monitors Printers Headsets Screens Projection equipment Servers Routers Hubs
Software	Administrative applications Licensing fees Educational programs File and network security Virus protection
Facilities	Wiring Classroom modifications: • air conditioning • chalkboard removal • carpeting, shade • positive pressure rooms Security • room and building • cables and locks for hardware Furniture and ergonomic considerations
Installation	Design specifications Contract oversight Technical staff

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Table 2. Breakdown of administrative and operating costs in calculating TCO for educational technology.

Cost categories	Costs
Technology Planning	Technical expertise Surveys Administrative time
Upgrade and replacement	Memory CPUs, Motherboards, Video and Sound Cards Software Operating system Monitors Printers Headsets
Internal support	Technical staff Replacement parts Consumable supplies • paper • printer cartridges
Support contracts	Fees / payments
Facilities	Air conditioning Electricity Telecommunications charges Discard charges

Table 3. Breakdown of end user operation costs in calculating TCO for educational technology.

Cost category	Costs
Staff Development	Substitute teachers Teacher training Peer Support
Teaching costs	Curriculum development
User Downtime	Technical problems Learning new applications

A variety of estimates of TCO for schools have surfaced in the last few years. Many analyses estimate TCO to be about $500 per pupil or about $2500 per computer for a very basic computing environment (that is, desktops connected to the Internet).[6] A 1996 report from the California Department of Education estimated costs for a four-year

[6] Work done by 'Taking TCO to the Classroom,' a project of the Consortium for School Networking, under the sponsorship of Intel Corp. and IBM Corp; <www.cosn.org>.

technology program at a school of 700 students with 33 staff to be $496 per student per year (California Department of Education, 1996). A 1997 International Data Corporation (IDC) survey of 400 school officials calculated TCO for a school with 75 computers at $2,251 per computer (IDC, 1997).

School technology may appear relatively cheap at first glance. After all, the Gartner Group estimates that the annual TCO for a networked PC in the private sector is over $9,000 (Baldwin, 1998). However, the low TCO in schools may not reflect the indirect costs resulting from a school's inadequate technical support and insufficient professional development. It is impossible to quantify lost productivity in schools, although there is some evidence that schools are underinvesting in technical support and professional development. The U.S. Department of Education recommends that 30% of school technology budgets go to staff training (Rosenthal, 1998), and the California Department of Education benchmarks for staff development and support are 21% of the total cost for a technology program (California Department of Education, 1996). However, the IDC survey found that schools spent just 6% on training and 6% on service and support (IDC, 1997). If the minimal investment in technical support and professional development manifests itself in significant downtime and underutilization, schools' cost "savings" may actually indicate a lack of investment. A comprehensive estimate of TCO includes both the time wasted by teachers when technology fails and the cost of resources being underutilized.

Policy Options: Paying Total Costs of Technology in Schools

One could argue that we chose the wrong schools to study the problems of managing and funding technology in schools. We knew these case studies to be success stories. The inner city elementary school has had a computer lab since 1984. New Haven School District is touted as a model for school technology programs. Broadway High School recently took top honors in a robotics competition and was cited for its emphasis on technology. Loara High School was one of the first schools to get a DHS Grant; clearly the high school is ambitious on the technology front. So, why study the "successful" schools, and not those that are struggling? Our answer is simple. We are

interested in *solving* the funding and management problems concerning educational technology, not just uncovering them.

Most of the problems associated with managing technology – another way to think about these problems is TCO – are best left to schools to remedy. For example, one way organizations have reduced their technical support costs and improved user satisfaction with computer networks is by identifying recurring problems and trying to find and correct their root cause. The inner city elementary school, for example, tried to eliminate many of the hardware problems they encountered with CD-ROM drives by installing a CD server. Instead of having to load CDs at individual workstations, teachers and students can access the CDs over the network. This type of problem solving minimizes TCO by reducing downtime and support costs, but it is not something the State can control. Is California going to require all schools to have CD servers? Or, is California going to send technical experts to schools to identify recurring problems and create user guidelines? Many well-intentioned regulations would undoubtedly meet unwillingness and indifference, if not outright resistance, at schools. Therefore, we compile a list of best practices – recommended school-level fixes – for managing technology (See Appendix 1). These practices may even consist of a state-level remedy: disseminate best practices to individual schools.

This section analyzes the state-level options for helping schools get the most from their investment in technology. If schools and school districts identify, plan, and manage TCO for technology, they will, by definition, have sustainable technology programs that are reasonably cost-effective. TCO for technology accounts for the long-term costs of technology; managing TCO means minimizing these long-term costs while trying to fulfill the objectives of the technology program. As we mentioned earlier, there are four systemic problems that prevent schools from addressing TCO of technology:

- Lack of sustained funding for technology.
- Lack of incentive to use technology efficiently.
- Lack of technical expertise in the schools.
- Inherent management problems associated with the rapid changes in technology.

These problems not only prevent schools from identifying and planning TCO for their technology programs, they manifest themselves in costs to schools, school districts, and ultimately, taxpayers, throughout the life cycle of owning technology.

State-level fixes may be suited to address these systemic problems common to most schools. In this section, we review what California, and to a lesser extent, the federal government, have done to date. We proceed to identify a few specific policy options that might fill the gaps in the current state policy.

The Current State of Policy

California has taken three recent actions to address the problems of owning technology in K-12 schools, including:

- Digital High School Grant (DHS Grant): a major spending initiative that allocates $500 million over four years to high schools completing the grant application process. Assemblywoman Figueroa has a bill on the table that would appropriate additional money to expand the DHS Grant to junior high schools (California SB 20).
- California Technical Assistance Project (CTAP): created to assist schools in completing the DHS Grant process and to serve as a regional clearinghouse of technology expertise for schools (CA Education Code, Section 52255).
- California Commission on Teacher Credentialing: new standards for computer proficiency for teacher credentialing and for the accreditation of teacher credentialing programs.

These actions (along with federal spending initiatives and other state proposals) begin to address the fundamental problems of TCO in K-12 schools.

Lack of sustained funding

Technology has a life cycle of costs. Yet, until recently, schools have only received funding for technology in one-time grants or refurbishment bonds. This makes it difficult for schools to budget for the full costs of technology, which makes it difficult for schools to stay reasonably current with technology used by the "real world." In the four case studies, each school had major sources of funding for technology, and had

established an impressive technology program. What happens when these funding sources run dry? If the schools are anything like one of the case studies, they will wait until the next funding source becomes available. This school waited 12 years before it replaced its Apple IIE lab with networked PCs, making the change only after a new funding source materialized. The state and federal government have made money available for the adoption of technology in schools, but have done little to ensure that TCO for technology is fully funded:

- The DHS Grant provides a matching grant up to $300 / pupil for technology over a four-year period. It also requires schools to submit comprehensive technology plans, provide matching funds, and use a portion of the funding for staff training.
- Perhaps the most reliable funding source for technology – once the details are worked out – will be the federal government's E-rate funds. The size of the fund is $1.925 billion per year. These funds come from taxes on telecommunications service providers (passed along to consumers) and are distributed to schools based on population density and the number of federally subsidized lunches a school distributes to its students. The funds can be used to purchase networking hardware (routers, hubs, and wiring) and to cover Internet and telecommunications costs.[7]
- In addition to E-rate, the Clinton administration has budgeted over $800 million in technology grants for schools. However, most are designed to foster creative uses of technology rather than sustain existing school technology programs.[8]

Despite the current funding sources, the pot of sustained money is limited. Although the DHS Grant is a step in the right direction, it only provides four years of funding (at most), and can not be considered "sustained funding."

It appears that only two ways of receiving sustained funding exist for schools. The first is to require schools to supply the sustained funding. California could require schools, regardless of where or how they obtained their technology, to set aside a certain

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[7] In June 1998, 63% of E-Rate funding had gone toward the purchase of internal connection hardware (eRATE UPDATE, 1999).

[8] One grant, the Technology Literacy Challenge Grant, encourages school districts to develop technology collaborations with companies and organizations to foster the effective use of technology.

dollar amount (or percentage) per computer for training, technical support, upgrades, and replacement. Schools would be responsible for finding this funding; in most cases, they would have to cut back other educational budget items. Or, California could provide sustained funding itself, as it has with the DHS Grant.

Obviously, both approaches have drawbacks, and neither is politically palatable. Requiring schools to set aside certain fractions of their budgets for the various aspects of owning technology is inefficient and inequitable. TCO for technology does not reduce to an equation, and budgeting in this fashion will prevent schools from tailoring their school budget to meet specific needs. In addition, schools least able to find ongoing funding from an external grant program would be hurt the most since they presumably would have to make tough budgetary choices to comply with the budget requirements. The second approach, full state funding, reflects a commitment on the part of California to provide technology in all schools. While California is funding initial and ongoing technology costs through the DHS Grant, a commitment to support all schools' ongoing technology costs would entail a massive investment. Full technology funding would likely become an additional revenue stream – similar to free lunch funding – that schools would try to maximize, and would not promote efficient management of technology.

Naturally, politicians and policymakers have steered clear of both avenues for funding TCO for technology in schools. Many, if not most, believe technology has merit in schools. However, no one wants to write a blank check – or just a big check for that matter – to help schools cover the long-term costs of owning technology. The "sustained funding" issue requires the State to determine the value of technology in education, something it appears unwilling to do.

Lack of technical expertise

Lack of technical expertise in schools affects all aspects of owning technology, especially incorporating technology into the curriculum and imparting learning benefits to children. California has tackled the problem through three traditional avenues: 1) regulation of who becomes a teacher; 2) prescribing staff development for the main technology grant program; 3) setting up an organization to assist schools.

Teacher credentials: In 1998, the State moved to increase the level of technical knowledge and curriculum integration in schools by raising the computer proficiency standards for teacher accreditation (California AB 1023). These new standards, adopted by the California Commission on Teacher Credentialing in December 1998, establish specific skill requirements for both preliminary and professional teacher credentials (for example, the use of e-mail and computer applications to manage attendance, assessment, and other school records).[9] In addition, the Commission adopted a series of supplementary measures aimed at increasing the technological proficiency of new teachers, including making adequate technology instruction a factor in the accreditation process for teacher credential preparation programs.

Grant requirements: To qualify for the DHS Grant, schools must demonstrate an intention to improve staff expertise in technology. The grant allocates funding for professional development in both the initial implementation grant and as part of continued funding.

Technical Assistance: There are 11 regional CTAP offices that help schools plan for technology and conduct staff training. The State Assembly is currently considering a bill that creates a Commission on Technology in Learning. This Commission would advise the State Board of Education on the implementation of technology in schools, develop a state master plan for school technology, disseminate technology resources, and develop guidelines for evaluating technology programs (California AB 598).

State actions in teacher credentialing make sense. The earlier teachers invest in learning how to use technology in the classroom, the greater the payoff will be in the long run. Requiring teacher credential programs to offer technology classes and incorporate technology into their classes, as California seems to be doing, is appropriate.

The last two state actions – grant requirements and technical assistance – could be interpreted as variations of "throwing money at the problem." There is no built-in mechanism for evaluating whether educators become more knowledgeable in technology as a result of the policies. However, this does not necessarily mean that the policies are inappropriate. Certainly, schools are in better positions to know their weaknesses and to

[9] http://www.ctc.ca.gov/CEAP/CEAP.html#TOP

address them. Money for staff development in the DHS Grants at least allows schools to make an effort in this area. A strong argument also exists for the formation of a small, state-level commission to stay on top of industry trends, collect and disseminate best practices and planning advice, and conduct inquiries to keep the legislature informed. Common sense suggests that these are important tasks that individual schools – even school districts – should not be forced to do on their own, if only because a coordinated effort would eliminate a tremendous amount of replication. While schools may decide to individually undertake some of these inquiries, the State still has an interest in conducting or contracting professional analyses of educational technology issues and disseminating the results to schools.

Lack of incentive to use technology efficiently

Schools do not operate in a competitive environment. Since education is not a product on the market, let alone a product that can be measured accurately, there is an inherent tendency for schools to either over-consume or under-consume technology. This creates a "feast or famine" mentality. When a one-time funding source becomes available, schools accumulate as much technology as they can get, without budgeting for TCO. Some tend to buy more technology than they can afford (to own) or put to effective use. Or, if there is no money available, they may continue to use outdated equipment that costs far more to upkeep than purchasing a replacement. These are the fears and anecdotes, but not necessarily what we observed in our case studies. However, feedback from CTAP lends some credibility to these fears. "When the schools get the money, they often forget all they did in the plan and revert to dividing up the funds and going many different ways." Or, "the plans that districts and schools have done by themselves are little more than thinly disguised shopping lists."[10]

California's response to schools lacking an incentive to use technology efficiently is to require planning, planning, and more planning. The DHS Grant uses its purse string to require a long-range plan approved by CTAP and the Education Council for Technology in Learning (CA Education Code, Section 52255). This is similar to the

[10] CTAP Region 7 Grant Coordinator.

federal government's E-rate grant that requires schools to submit a "technology plan" before being eligible for funding.

The state action requiring planning is effective to the extent that the people filling out the forms understand why the State is requesting the required information. With a relatively new responsibility, like incorporating a technology program into a school, the state-mandated planning requirements are simply a way of preparing (or educating) schools on the challenges of implementing such a program. Schools that develop strategies to overcome these challenges – staff development, technical support, finding matching grants, time commitments, etc. – will be more likely to have a successful technology program. In addition, requiring schools to develop technology plans is an accountability tactic that public officials use to justify the spending to their constituents.

The main limitation of planning requirements is that they can quickly become just "another state requirement." Currently, planning is treated as a "YES" or "NO" enforcement mechanism to make schools use technology efficiently. However, if schools get a "YES" from an agency distributing the money, does this guarantee schools will use the technology effectively? Planning and practice are two different issues. If planning gets too formulaic – administrators can attend workshops to learn how to submit "acceptable" plans to receive E-rate funding or a DHS Grant – its effectiveness may dwindle.

Inherent problems in managing technology

The pace of change in technology is speeding up and technology is becoming more widely distributed and more personalized. The State's proposal to develop a state commission on technology – a new version of CTAP – addresses this problem by creating a centralized information clearinghouse. As stated earlier, most teachers have neither the time nor the expertise to keep up with innovations in hardware, networking, and educational software. However, the success of technology programs appears to be related to a school's ability to develop a program that best fits its needs. The inherent changes in technology make the problem of technical expertise in schools more acute, and could justify a centralized body with sufficient expertise to act as an information clearinghouse and an advisory body.

Policy Options

In this section, we offer three policy options that policymakers should consider to help schools use technology more efficiently. They are: 1) require schools to have separate budget accounts for technology; 2) split up the distribution of state funding for technology into four different phases; 3) create a small grant program to allow school districts to experiment with different models of technical support. These options strike a balance between encouraging schools to plan and budget TCO for technology while preserving schools' autonomy to respond to local needs. We evaluate these and other policy options on criteria such as cost to California, political and organizational feasibility, and school-level concerns.

We did not analyze several options in this study. We did not consider expanding existing funding since it is safe to assume that most lawmakers are well aware of this option and that it will play out in the political arena. This option requires policymakers to make a cost-benefit assessment of technology in K-12 schools, something that is highly controversial and beyond the scope of this paper. We also do not recommend any action to address teacher training. Many options in this area are affected by the unionization of teachers.[11]

Technology budgeting requirement

We first recommend that all schools have separate budget accounts for technology in the school budget. Obviously, schools need not have a technology budget that reflects all aspects of TCO for technology discussed in this report. However, the major factors in TCO (technical support, training, hardware, and software) should have separate accounts in a school technology budget. These accounts could be standardized across schools.

The intent of our recommendation is to help schools identify and allocate money for ongoing costs. All organizations that use technology wisely budget for technology. But many schools do not. Schools and school districts can not begin to make informed decisions about how to allocate scarce budget dollars without knowing how much they

[11] For example, salary increases for documented gains in technology proficiency would be a way to encourage current teachers to master and integrate new classroom technology. Many teachers get "credit" (salary points) for continuing education courses. However, the teachers' union has successfully fought incentive-based pay and other merit schemes.

spend on technology. What aspects of owning technology are expensive and could be improved? A line item budget requirement for technology would help schools identify and plan TCO for technology.

This recommendation would not impose an unreasonable burden on schools. Schools would retain complete flexibility over how they spend their money. Because of the variability of school needs, we do not recommend establishing minimum requirements for the various technology accounts (for example, a 10% minimum of technology funds for teacher training). Schools could also have flexibility with how they budget for technology. They could create itemized budgets in one of three ways: 1) object classification allocates money by items to be purchased; 2) administrative classification assigns money by bureaucratic unit or department; 3) mission classification allocates money for specific programs. The State would need to decide whether to require a standardized budgeting technique.

Funding phases for technology grant program

Our second recommendation requires that state funding for technology programs be divided into separate phases. By splitting up the funding cycle, the State could require schools to submit evidence demonstrating their readiness to proceed to the next phase of implementing a technology plan. Currently, the State requires schools to submit a technology plan before they receive funding for the DHS Grant. However, once this plan is approved, schools automatically receive funding for the next four years. This could be wasteful, especially if a technology plan is nothing more than a shopping list. In reviewing and approving schools' technology plans, the State has only one opportunity to determine whether schools will meet their stated objectives.

Breaking up the funding cycle will make schools more accountable for implementing their plans, and it will give the State more opportunities to check that schools are fulfilling their technology objectives. To secure the next round of funding, schools will need to submit documentation, or "evidence," that they are implementing their technology programs and making efforts to manage their program efficiently. Any organization adept at adopting technology could furnish the evidence we envision the state requiring. Being able to produce this evidence is a minimum (by no means

sufficient) condition for managing technology efficiently. Importantly, this type of evidence does not require extensive evaluation. The reviewing agency, currently CTAP, would not be in the business of evaluating how individual schools are using and managing technology. CTAP will have basic criteria for determining whether "yes, the school qualifies for the next phase of funding," or "no, the school needs to supply additional evidence."

This funding scheme has two additional benefits. First, it would provide funding for planning itself, which would give schools an incentive to spend less time applying for technology grants, and more time properly identifying, and planning, the TCO for technology programs. The current funding structure discourages planning by making schools pay these costs out of their existing budget. Second, breaking up the funding cycle addresses equity issues. Since our proposed funding cycle provides initial funding for planning efforts, it may help schools with fewer resources plan for (and receive) technology on par with better-situated schools. It also gives CTAP more built-in opportunities to provide assistance to schools.

We recommend that funding for technology programs be separated into the following four phases: 1) Initial Application and Pre-planning; 2) Comprehensive Technology Plan; 3) Implementation; 4) Ongoing support.

Phase One: Initial Application and Pre-planning. The first phase requires schools to provide the following pieces of information:

- Show evidence of commitment from the principal, teachers, and staff.
- Produce matching funds (or a waiver of this requirement) in existing computers or money set-aside in their budget.
- Identify a person who understands technology and is willing to take responsibility. Most likely, this person will be a teacher who is familiar with the school community and curriculum.
- Assess the current status of teacher proficiency with technology and describe strategies to improve existing computer skills and use of technology in the classroom.

Once schools submit satisfactory evidence of the type listed above, they will receive the first installment of funds. Schools will use this money to develop technology plans and begin professional development in technology. Schools will also receive a "planning tool kit" that disseminates "best practices" and other helpful pointers for owning technology.

Phase Two: Comprehensive Technology Plan. In phase two, schools develop a comprehensive technology plan that outlines both the technical specifications of the program and how the school plans to integrate technology into school curriculum (See Appendix 1 for description of comprehensive technology plan). The State could also require schools to submit Request for Proposals (RFPs) for the installation of equipment and for technical support. RFPs are what schools send out to potential suppliers of technology services. They document exactly what schools want in terms of services, and suppliers make a proposal to deliver the services. Producing RFPs is a best practice in managing technology because it helps guarantee that the organization gets the services it wants for the lowest cost. Requiring schools to produce and distribute RFPs will help schools determine whether their technology plans are realistic. Schools will find out what the marketplace has to offer, instead of relying solely on the school district. Some schools might even decide to go with a third party provider.

Phase Three: Implementation. Schools that submit technology plans and receive state approval will obtain funding to implement their technology programs. Schools can now begin to put their plans into action.

Phase Four: Ongoing Support. To qualify for continued funding, schools must provide additional evidence documenting that they are managing technology efficiently. This evidence includes:

- An inventory list of technology assets.
- Service level agreements (written contracts between the users and suppliers of technical support).
- Professional development status report.
- Annual line-item technology budget.

- Annual self-evaluation that describes the school's progress in meeting objectives of the technology program (as stated in technology plan) and enhancing student achievement.

Any organization adept at managing technology could furnish the foregoing list of documentation with relative ease. The documentation represents underlying management practices such as periodic assessment, formal expectation setting, budgeting, and ongoing professional development. The incentive for schools to undertake these successful management practices is imbedded in our funding scheme: continued funding is contingent on evidence that these practices are in place. We realize, of course, that evidence alone is no guarantee that schools will actually undertake these management practices. But if they should be adopting these practices, we see no reason why the State should not require this evidence.

Despite the paperwork entailed in our funding scheme, we do not think it would be too costly to schools or the State. Although these funding phases could increase the schools' costs, the costs would be dispersed over an extended period of time. In the long run, the goal of funding phases is to reduce schools' costs by requiring them to plan (and minimize) TCO of technology. The cost of administering this program would be minimal to the State, since it would rely on the same mechanism it currently uses to review DHS Grant applications, the California Technology Assistant Project (CTAP). Our recommendation would require CTAP to use a simple "YES" or "NO" measure to review school documentation; CTAP would not evaluate how individual schools are using and managing technology. For example, a "YES" approval for phase one would only require that certain documents be completed to the satisfaction of CTAP. Such a process would not require CTAP to evaluate whether the school has a sufficient amount of technical proficiency, just that they have reviewed this item and are planning to do something about it. CTAP would also maintain its current responsibility of assisting schools with the funding applications and the preparation of the required documentation.

CTAP, or any other agency reviewing the funding applications, should be required to respond to a school's request in a certain amount of time, especially given the "YES-NO" nature of the evaluation. These pre-determined timelines would vary among

the four phases, as each phase requires a different type of review. For example, the pre-planning phase could have a 15-day turn-around time, and the planning phase could have a 30-day period.

Our recommendation focuses on the delivery of appropriations earmarked by the legislature and the governor for school technology programs. Although the distribution of funds would be separated into four different phases, the State would continue to appropriate the funds annually into a single account. The legislature and the governor do not need to anticipate the demand for each phase; rather, the California Department of Education would have discretion over how the total amount is distributed.

Our recommendation preserves the flexibility of schools to adopt the level and type of technology that best meets their student-based objectives. It inserts more "YES-NO" mechanisms into the current grant system, which only requires the evaluation of one document, the technology plan. We believe this makes schools more accountable for implementing their technology program and planning for the long-term costs of owning technology. To receive the next phase of funding, schools will have to show evidence that they have adopted best practices. Our recommendation should make schools do things that all organizations adept at using and managing technology do, leading to better designed and better managed school technology programs.

Grant for experimental technical support and administration model

One of the tensions in technology management, documented in our case studies and research, is between schools and their respective school district. Schools often expect (and require) support from the school district when they purchase technology, placing a burden on the school district that the district can not control. Of course, the school district could coordinate all technology investment and management. However, schools would then lose their autonomy. Many schools are already dissatisfied with the responsiveness and quality of school district support, but have no alternatives since district support and assistance is "free".[12] Our recommendation would create a grant for

[12] School district level support is funded from general education dollars disbursed by the State to school districts. The school district takes a small portion from every school's general funds before disbursing the funds to the schools. Individual schools can maximize their general educational budget by maximizing the resources they receive from the school district.

one or two school districts to experiment with transforming their technical services from a cost center to a revenue center. In this service model, schools would have greater choice for technical support and the school district would have an incentive to become more responsive to schools and grow its technical services in accordance to demand.

There may be economies of scale to be gained in aggregating technical support and network administration at the school district level. In theory, a school district should be able to provide an equivalent level of technical support to schools with fewer people than if each school had its own technical support person(s). If a support person has downtime at one school, he or she could be solving a problem at another school. In addition, with a staff of technical support people (school district support staff can number up to 30 or 40 people), the school district has the scale to implement basic management practices such as creating a career path, conducting ongoing training, and investing in technology (for example, help desk software or telecommunications features) to improve its operations. However, there is no reason why a school district needs to provide these services to schools. In fact, there are numerous companies that provide "outsourced" technical support and administration services.

Without requiring that all schools receive technical support from their respective school districts, and without requiring that all schools outsource technical support to private contractors, we think that the relationship between school and district could be improved in the area of technical support (all ongoing technical services such as "how to" software inquiries, hardware problems, network administration, upgrading, etc.). The provision of technical support to schools would be more efficient if the relationship between schools and school districts was based on a few principles: 1) schools should have control over their share of the school district's technical support budget; 2) schools should have to bear the full technical support costs associated with their technology investments; 3) school districts need to be able to gauge demand for their services, including the level and type of support a school desires. In theory, a relationship based on these principles would enable the school district to better meet demand and provide schools with more flexibility.

We propose that California set up a small grant program to allow one or two school districts to experiment with a support model based on these principles. We briefly describe a model that might be considered for receiving such a grant below. The grant needs to give an adequate incentive for school districts to try this model, and should reflect the difficulties with reorganizing district-wide support. At a minimum, the school district would need a sophisticated computer and telecommunications system. We recommend that the grant fund the full costs of a school district owning such technology, which could be as much as $200,000, with ongoing support of $100,000 / year for some extended length of time.

While a grant of this size is not inconsequential, we nevertheless recommend its creation without formally assessing its costs and benefits. First, we think that the State could probably find money for such a grant from one of the federal government's "innovative technology grants," or from one of the foundations or corporations active in this area. Second, the new relationship between school and school district would directly address the problem of schools lacking an incentive to manage technology efficiently. Few policy options directly address this problem, and yet the problem will continue to persist as schools invest in technology. The grant would provide a very important case study for crafting additional policies to provide incentives to schools to manage technology efficiently, a benefit we think would equal its cost.

One experimental support model that might win such a grant could work along the following lines. Money currently going to school district technology support would be disbursed directly to schools. Schools could either contract support from the school district, provide support in-house, or outsource support to a private firm. In either case, schools would pay for the technical support they receive. The price they pay would be based on the cost of the support, including a normal rate of return. To ensure that school districts are keeping their costs down, their contracts with individual schools could be periodically put up for bid as a single, district-wide, support contract. Such a model would: 1) make the cost of technical support explicit to schools; 2) make schools plan TCO for technology, or, at least, the support component of owning technology; 3) improve the operations of school district technical support. The school district technical support function would become a revenue center instead of a cost center, and it could

potentially grow its business by taking on support for programs affiliated with schools (for example, private schools, after-school programs, and non-profit outreach programs).

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Appendix 1: "Best Practices" for Managing School Technology

In this section, we list the "best practices" for each phase of the life cycle of owning technology: planning, funding/budgeting, purchasing, supporting, and upgrading/replacing/discarding. We derive this list from the four case studies, conversations with people who have an interest in educational technology, and existing literature and research.

While the main portion of our report is written for policymakers, the purpose of this section is to address the needs of educators: administrators, teachers, and school technology managers. Our intent is to summarize the "good advice" we collected and to provide insight for people in the trenches who are directly responsible for the "technological revolution" in K-12 education.

Planning for Technology

1. *Develop a technology plan:* Implementing a technology program can be an overwhelming task. By developing a technology plan, a school identifies future challenges and devises strategies to overcome them. A comprehensive technology plan includes:[13]
   - School "technology vision," or mission statement.
   - Description of the computer knowledge and skills taught to all students.
   - Description of how the school ensures technology access for all disabled students.
   - Explanation of how the school integrates technology into curriculum, instruction, and assessment.
   - Description of the technology infrastructure on school campus, including existing hardware/software and wiring specifications.
   - Plans for professional development.
   - Assurance that the electronic equipment is compatible with state-level standards.
   - A budget account for technology that incorporates TCO.
   - Plans for ongoing support and maintenance (i.e., service level agreement).
   - Plans to assess the effectiveness of the program, including student achievement and professional development.
2. *Obtain support from school community:* Creating a technology plan requires a commitment from an entire school community: administrators, teachers, students, parents, and city leaders. It also demands a large portion of time. Ultimately, a

[13] Adapted from CA Education Code, Section 52256 (Chapter 326, Statutes of 1997, AB 64).

technology plan will emerge that represents the various actors of a school community in the form of a coherent and unified technology vision.

3. *Support reluctant educators:* Realize that some teachers will be skeptical of using technology in the classroom. Rather than ostracize them, listen to their concerns. Show teachers how technology can supplement a variety of teaching philosophies, and provide training that is appropriate to the experience level of the user.
4. *Appoint a Project Manager:* Select a person to serve as the technology project manager and coordinate planning efforts. Making a person accountable to oversee the technology project will keep it on track. In addition to having a general understanding of educational technology, this person must relate well with the school community, acknowledge the educational objectives of the school, and be familiar with California's technology standards.
5. *Survey school community:* Conduct a survey to gauge (and build) interest and support of school community.
6. *Assess proficiency of teachers:* Assess the current level of proficiency among teachers. Computers should be placed in classrooms only after a teacher demonstrates a level of expertise, including the ability and desire to integrate technology into the school's curriculum.
7. *Observe other schools:* Travel to another school and observe its technology program. Much can be learned from a firsthand glance at a technology program in action. Talk to educators who have already gone through the "planning" process.
8. *Ensure compatibility:* Check that the school's technology plans are compatible with district-wide plans.
9. *Develop long-term goals:* Develop long-term goals and revisit them on a regular basis. The rapid pace of change in educational technology can make a technology plan obsolete in a short period of time.
10. *Do not forget about the details:* Determine electrical requirements during the "planning" phase, not when computers are ready to be installed. Use professionals to obtain the requirements for cabling and other electrical concerns.

Funding and Budgeting for Technology

1. *Track government funding*: All three branches of government – federal, state, and local – provide funding for educational technology, primarily through the distribution of grants or local bonds. Schools that monitor these technology grants have an advantage when it comes to funding.
2. *Track non-profit and private sector funding:* Many non-profit organizations and private sector companies provide substantial grants targeted directly for educational technology programs. Schools can solicit funds, technical expertise, and equipment.
3. *Create school web site:* Create a school web site that describes the school's technology program, including a link that acknowledges donors.
4. *Explore partnerships:* Search for an organization that could use the computer facilities after school hours. These organizations could pay the school to use its computers after school hours. Schools can also develop partnerships with local agencies and combine assets. For example, schools could open their computer resource center to the public and receive financial assistance from the local municipality.
5. *Formulate an itemized technology budget:* Itemize technology expenditures in the school budget, and develop ways to track costs. These line items should account for TCO of the technology program.

Technology purchasing

1. *Collaborate with school district, if possible:* Schools that have a good working relationship with their school district may have an incentive to let the district purchase technology items. Most school districts that purchase technology have a "professional technology team" that reviews a school's shopping list before placing the order. Although some schools may feel threatened by this monitoring role, it also serves as a helpful (and free) consulting service. Advantages of having a school district purchase technology include: 1) buy in bulk, and reduce costs; 2) track schools' technology inventory; 3) provide assistance. At some schools, the school district guarantees to offer technology support on the items that it purchases.
2. *Write Request for Proposals (RFP):* Write a detailed RFP for major installations or services that pass the inspection of technical experts. For network design and

installation, a network engineer should review the specifications before the bidding process begins.

3. *Compare support services:* Before purchasing, factor in support guarantees and services rather than being sold on performance alone.
4. *Consider recycled computers:* Shop for recycled computers, but check that they meet the objectives of the technology project, not just the budget requirements.
5. *Consider leasing:* Consider leasing a computer facility. The actual owners are responsible for maintenance and upkeep.
6. *Bargain rates:* Purchase technology through educational consortia that provide discounts for either "bulk" or "educational" purchases.

Support for Technology

1. *Create Student Technology Support Team:* Students are often better equipped to use technology than teachers. Schools accepting this fact can bolster their technology programs by giving students credit (equivalent to teaching assistants) to serve the technology needs of the school. This team of students assists the computer technology manager in professional development, support, upgrades, presentations, and other uses of technology.
2. *Standardize:* When appropriate, standardize software and hardware throughout the school.
3. *Manage remotely:* Establish a remote management system. In a networked environment, the administrator can load software and keep track of assets and applications remotely.
4. *Identify and address recurring problems:* Identify recurring problems and fix the root cause. Some businesses identify personnel who seem to always require technical support and address the problem by providing them with training.
5. *Communicate:* Develop a communication system with users to inform them of upgrade schedules, common problems, and tips. Establish a user-friendly protocol for reporting technical problems. Make sure that a clear hierarchy for correcting problems exists.

6. *Create Service Level Agreements (SLAs):* These are quasi-contracts between users and suppliers of technical support. They set expectations regarding response time, procedures, and the types of problems supported.

Technology Integration

1. *Lead by example:* Administrators should use technology and expect teachers to do the same.
2. *Provide incentives:* Provide incentives for teachers to be adopters of technology.
3. *Be creative:* Establish pilot programs that integrate technology into the school's curriculum. Teachers should be encouraged to experiment with technology in the classroom.
4. *Collaborate:* Set aside time in the school week for teacher collaboration on technology use.
5. *Formalize training:* Set up a training program with different levels of proficiency. Track and provide feedback on individuals' progress. Designate a training coordinator.

Upgrade, Replacement, Discard

1. *Budget for upgrades:* Technology is rapidly changing, budget for upgrades.
2. *Compare discard versus replacement:* Track support costs to see when discard and replacement will be cheaper than providing maintenance for older technology.
3. *Agree to a replacement rate:* Schools should identify a replacement rate that gives the school enough "top-of-the-line" computers, while preserving some older computers for basic computer skills.

Appendix 2: Loara High School

Overview of School

Size, Location, and Demographics: Loara High School (Loara), a California Distinguished School, opened in 1962 and is currently one of eight high schools in the Anaheim Union High School District (AUHSD). Total student enrollment at Loara is 2,067. Its ethnic diversity (45% Hispanic, 33% Caucasian, 14% Asian, 3% African-American, 3% Filipino) is reflected in the relatively high percentage (35%) of students identified as Limited English Proficient. Fifteen percent of the students who attend Loara participate in the Gifted and Talented Education (GATE) program.

The staff at Loara comprises 87 teachers, 50 support staff, three counselors, three assistant principals, and a principal. Loara received a six-year WASC (Western Association of Schools and Colleges) accreditation in 1993. In the fall of 1998, Loara received over $620,000 from the Digital High School Education Technology Grant (DHS Grant) to implement the Loara Digital High School Project (Loara DHS Project).

Overview of Technology Environment: The Loara DHS Project provides all students with opportunities to learn about computers while developing basic literacy skills. Students receive training on Macintosh and IBM computers. All students have access to computers through: 1) a Student Technology Resource Center (STRC), located adjacent to the school library; 2) access to computer laboratories in business, art, science, and special education classes; 3) certain classrooms equipped with on-line capabilities.

Tables 1 and 2 display the computer inventory before and after the implementation of the Loara DHS Project.

Table 1: Computer Inventory (before implementation of the DHS Grant)

	Computer Lab	Classroom	Library Media Center	Other Locations
Apple/Mac				
a. Apple II/IIe/GS	-	39	1	-
b. Mac LCII or earlier	37	43	-	-
c. Mac LCIII (68030) or later	35	4	-	-
d. Mac Quadra/Centris (68040)	3	3	-	-
e. Mac Power PC	11	31	-	-
f. Mac Powerbook	1	8	-	-
g. Number of above that are				

Internet capable	48		1	
h. Number of above that are Multimedia equipped	14	43	-	-
PC Compatible				
i. 286 or earlier	16	1	-	5
j. 386	-	1	-	-
k. 486	-	10	-	-
l. Pentium (586-686)	37	37	9	7
m. PC Lap Top	-	-	-	6
n. Number of above that are Internet capable	2	74	-	1
o. Number of above that are Multimedia equipped	2	89	-	2

Table 2: Expected Inventory (after implementation of DHS Grant)

	Number in Loara DHS Plan
Teachers: Computers with multimedia and Internet capabilities for exclusive use by teachers in classrooms	8
Other computers for exclusive use by teachers in classrooms	22
Other computers for exclusive use by teachers elsewhere	8
Students: Computers with multimedia and Internet capabilities accessible to students in computer labs	94
Computers with multimedia and Internet capabilities accessible to students in shared or common space (e.g., library)	5
Other computers accessible to students in classrooms	16
Other computers accessible to students in computer labs	64
Other computers accessible to students in shared or common space (e.g., library)	5

Technology Planning and Funding

Technology Planning Process: The planning process was a fundamental component of the Loara DHS Project. Planning provided the school an opportunity to reflect on its objectives, to discuss its options, and to articulate its vision. Loara's principal noted that strategic planning reduced unnecessary spending on technology equipment, especially during the implementation phase. For the Loara DHS Project, planning was fundamental to its success.

Loara first defined "technology." After much debate, the school identified technology in broad terms, not limiting the definition to only computers, but including other "traditional" items (calculators, overhead projectors, TV's, etc.). Next, Loara sought out the technological needs of its students and faculty. The school accomplished

this goal by surveying students, parents, faculty, and staff. The results of the surveys were analyzed and discussed among members of the Technology Committee. This committee, under the leadership of Loara's principal, consisted of representatives from the student body, faculty, administration, and community. Its main responsibilities were to develop a common vision for the Loara community, to identify the objectives of the technology program, and to submit an application for the DHS Grant.

Source of Vision and Initiative for Technology: Loara envisions an educational system where students demonstrate knowledge in four domains comprising ten major skills. These four domains, or Expected School Learning Results (ESLRs), help guide the Loara DHS Project (Table 3). To meet these four educational domains, new ways of teaching and learning are necessary; Loara relies on technology as the tool to foster this innovation.

Table 3. Student Skills and Knowledge

	EDUCATIONAL DOMAINS	STUDENT SKILLS AND KNOWLEDGE
1	BASIC ACADEMIC AND VOCATIONAL SKILLS	▪ Read with comprehension ▪ Write with clarity ▪ Speak articulately ▪ Calculate efficiently ▪ Listen and understand
2	TECHNOLOGICAL SKILLS	▪ Increased competency in the use of computers to manage information ▪ Understand the application of technology to everyday life
3	INTERPERSONAL SKILLS	▪ Accept responsibility for decisions and actions ▪ Work together in diverse settings
4	LIFELONG ACADEMIC AND VOCATIONAL SKILLS	▪ Participate in academic vocational classes and activities leading to a career pathway and higher education

Loara predicts that a successful implementation of the Loara DHS Project will see the following results:

Students

- Increased achievement in academic areas, with performance aligned with the subject matter content standards for language arts/reading, mathematics, social studies, and science.
- Increased development of computer literacy, including skills in word processing, data entry, presentation software, spreadsheets, and telecommunications.
-

Faculty and Staff

- Increased computer usage and proficiency in word processing, data management, and presentation applications, with ongoing computer training for new staff members.
- Increased usage and integration of basic and advanced technology skills into curriculum.

Curriculum and Instruction

- All curriculum areas include units that require increased usage and integration of basic and advanced technology skills.
- Individual departments and programs provide increased access to discipline-specific technologies and new technology skills.

Facilities

- STRC staffed by support technician and accessible before, during, and after school hours.
- Presentation modules for classrooms connected by an integrated network linked to city library.
- Cable television access in every department.
- Library connected by an integrated network to city and community college libraries.

Funding: The Loara DHS Project receives most of its funding from the DHS Grant. However, this grant requires that Loara obtain matched funding. Table 4 breaks down the sources of funding and Table 5 displays the allocation of funding.

Table 4: Funding for the Installation of the Loara DHS Project[14]

Major Object of Expenditures	Digital High School Funds	Local Match Funds	Total Funds by Object Expenditure
1. Certificate Personnel (Salaries)	$37,206	-	$37,206
2. Classified Personnel	$30,357	-	$30,357

[14] The first row in Table 4 (Certificate Personnel) represents the management of the technological system by faculty members; the second row (Classified Personnel) is for the STRC Technicians; the third row is for these employees' benefits. The fourth row is for the purchase of software and technological materials. The fifth row is for staff development, the STRC technicians, and program evaluation. The sixth row represents the school district's estimated costs of implementing the program. The seventh row is for the purchase of computers, printers, scanners, and installation of a LAN system. Purchases also include electrical panels, floor molding, STRC security alarm system, PC and MAC servers, and Tele-conferencing hardware.

(Salaries)			
3. Employee Benefits	$3,704	-	$3,704
4. Books and Supplies	$24,897	$29,239	$54,136
5. Services and Other Operating Expenses	$53,451	$50,536	$103,987
6. Indirect Costs	$6,463	-	$6,463
7. Capital Outlay	$464,000	$925,567	$1,389,589
TOTAL FUNDS	**$620,100**	**$1,005,342**	**$1,625,442**

Table 5: Allocation of Funding for the Loara DHS Project

PROGRAM COMPONENT	DIGITAL HIGH SCHOOL FUNDS	LOCAL MATCH FUNDS	TOTAL FUNDS BY COMPONENT
A. Program	$385,485	$905,365	$1,290,850
B. Staff Development	$50,951	$15,536	$64,487
C. Technology Infrastructure	$134,307	$76,842	$211,149
D. Parents and Partnerships	$1,500	$2,099	$3,599
E. Sustainability	$15,000	$0	$15,000
F. Project Management	$30,357	$2000	$32,357
G. Evaluation	$2,500	$2,500	$5,000
TOTAL FUNDS	**$620,100**	**$1,005,342**	**$1,625,442**

A brief description of each "Program Component" follows:

A. Program: The basic assumption of the Loara DHS Project is that technology resources are teaching and learning tools. While students learn the basics of using these tools, it is also important that they utilize these tools daily in the classroom. Thus, Loara integrates technology into all content areas and expects that students use technology daily. The plan ensures fair and appropriate access to technology for all students, and provides them with an opportunity to explore career and college information. The program focuses on student achievement in two ways:

(1) *Students develop threshold proficiency.* Students will first become proficient in word processing, spreadsheet and data processing applications, and the use of CD-ROMs, e-mail, and the Internet.

(2) *Students develop advanced proficiency.* Students will take advanced computer courses and begin to incorporate their newly acquired computer tools into classroom activities.

B. Staff Development: This program component ensures that each staff member, including classified staff and administrators, will become computer literate and

knowledgeable in utilizing various forms of technology in the classroom to improve student learning. A more thorough analysis of "professional development" is discussed later in the case study.

C. Technology Resources: The Technology Committee formulates school-wide technology goals and coordinates the redistribution of equipment. All resources are directed toward the increase of student achievement and increased computer literacy.

D. Parents and Partnerships: Parents are a vital part of the Loara DHS Project and are involved in planning, implementation, and evaluation. Parent volunteers receive training and will provide additional staffing for the Library Media Center and STRC. In addition, several local businesses, colleges, and local agencies provide materials, human resources, and financial assistance.

E. Sustainability: In the first three years, Loara will be sustained through the DHS Grant and local support. The administration seeks additional funding through grants, expanding partnerships, volunteers, and the use of student technicians.

F. Project Management: The principal, an assistant principal, and the Technology Committee serve as the DHS Management Team. The team meets monthly to plan and evaluate training, monitor equipment installation, facilitate the integration of technology into the curriculum, and evaluate the progress of the project.

G. Evaluation: The Loara DHS Project includes specific evaluation strategies that will provide both formative and summative information. In December and June of each year (every six months), evaluators will collect data that assess the progress in reaching the technology program's goals. This data includes student achievement measures (for example, Stanford 9 Achievement scores, performance standards, CTBS scores, student multimedia projects, writing scores, etc.).

Contracting and Purchases: The AUHSD handles the technology contracts and purchases for the Loara DHS Project. The school district monitors this process for several reasons:

- Loara receives free technical support (from AUHSD) on all products purchased through the school district. This reduces costs and allows Loara to focus its resources on other objectives.
- The school district has a technology support staff that is accessible and free.
- The school district has an experienced educational technology team that purchases the technology products needed for the Loara DHS Project.
- The school district can receive "bargain" rates from competitive bidders, often at "bulk" rates.
- Loara is not harassed by pushy vendors or consulting companies.
- The school district and Loara have a relationship built on trust and mutual respect.

A drawback to the current system is the amount of time that it takes for Loara to decide, to order through the school district, and to receive technology products. This process can take from three weeks to three months. Nonetheless, Loara's principal believes that the benefits outweigh this negative factor.

Management of Technology

Installation and Implementation: Loara is still in the implementation phase of its project. Areas that were given initial priority included the STRC, the Business Education Computer Labs, and the school's library. In subsequent years, additional technology improvements will be made, including a library server to accommodate Web pages and facilitate communication between teachers, staff, students, and parents and to showcase student learning.

Ongoing Maintenance: As mentioned earlier, the school district is responsible for supporting the technology that it purchases. Either the school district's technology team or a contracted private company will provide the necessary support. This is a cost-effective strategy for the Loara DHS Project.

To provide ongoing technical support for the "every day" problems, a technician will be hired to oversee equipment maintenance. Teachers who are experienced and interested in technology also play an important role in network management. Ultimately,

students with advanced computer application skills will be trained to support staff members with trouble-shooting and will earn school credit as teaching assistants.

Upgrade and Discard: Like most schools, Loara has outdated computers that are not used. Some of these are stuck in forgotten corners of classrooms, but most are passed along to the Regional Occupation Program (R.O.P.) center. Fortunately for Loara, the R.O.P. is located on campus and serves as a vocational school where adults learn how to "fix" computers. The R.O.P. welcomes the discarded computers as they provide hands-on "tinkering" material for the adult students.

Professional Development: Professional development is an important component to the Loara DHS Project. As stated earlier, the objective of staff development is to ensure that staff members, including classified staff and administrators, are computer literate and knowledgeable in utilizing various forms of technology within the classroom to improve student learning. All staff members (100% response rate) completed a survey and attended a conference period to determine their interest and proficiency levels with a variety of technological tools.

The survey revealed that most staff members had basic computer and word processing skills but needed advanced training in video production, multimedia applications, and use of the Internet. Loara will address these needs over the course of three years, and upon completion, teachers will:

- Make effective use of hardware and software available on campus.
- Access the Internet for projects, research, and curriculum development.
- Support the development of student skills in research, collaboration, critical thinking, and writing.
- Facilitate interdisciplinary projects.
- Design learning activities that integrate technology into the curriculum.

Table 6 displays the percent of staff that require training, with a description of the training that will be provided. This training is broken down into four phases -- Personal Proficiency I, Personal Proficiency II, Instructional Proficiency I, and Instructional Proficiency II.

Table 6: Professional Development Needs.

TRAINING PHASES (Faculty and Staff)	PERCENT OF STAFF IN NEED OF TRAINING
PERSONAL PROFICIENCY I Basic word processing and data management, grade programs, clip art, and simple graphics, CD-ROM	11%
PERSONAL PROFICIENCY II Telecommunications (as a resource and as an instructional device), specialized technology equipment	24%
INSTRUCTIONAL PROFICIENCY I Multimedia presentations design and implementation	56%
INSTRUCTIONAL PROFICIENCY II Curriculum development and implementation support (to be organized by subject matter areas in alignment with the development of content and performance standards-beginning with language arts/reading and mathematics)	100%

Unanticipated Costs and Difficulties

Loara's principal stated that the Technology Committee actually planned for "unexpected costs." These turned out to be little things that are often overlooked. For example, the computer labs had to be carpeted, air conditioning installed, swivel chairs supplied, an alarm system activated, and telecommunications wiring implanted into the walls. The best way to deal with unanticipated costs (every school will have different costs) is to realize that they exist.

No matter how much strategic planning a school undergoes to implement a technology project, the school will confront challenges along the way. The biggest challenge facing the Loara DHS Project was "time." The DHS Grant had a strict deadline that Loara had to meet. The Technology Committee was asked to spend many hours (unpaid) developing and revising the technology plan and grant application. This was a burden on the members of the committee who already had extremely busy schedules.

Lack of computer knowledge was also a difficulty that confronted Loara. Most of the staff had basic computer skills, but few had the experience required to implement a million-dollar technology program.

Developing a common technology vision was another challenge that the school faced. This was a difficult task because a variety of interests--administration, faculty, staff, students, and parents--had to be met.

Summary: Analysis of Lessons

The Loara DHS Project was not thrown together overnight. A Technology Committee, representative of the entire school community (teachers, staff, administrators, students, parents, and civic leaders), carefully thought out the concept of integrating technology into the curriculum. This committee developed a common vision from a variety of individual interests. This vision has guided the technology project from the start; it will continue to lead the project into the future.

The committee's first step was to gather data regarding the existing technical status of the school. It then sought the opinions of the school community and, from this information, created a list of objectives for the Loara DHS Project. From these objectives, four goals emerged:

1. To increase student achievement.
2. To increase students' computer literacy skills.
3. To provide intensive staff development to increase teachers' computer skills and insure the effective use of technology across the curriculum.
4. To install and maintain the necessary network and infrastructure for the Loara DHS Project.

The Technology Committee then submitted an application to California's DHS Grant. After several months (and several drafts), Loara was rewarded with an opportunity to become one of the first high schools to receive over $620,000 in state funding to implement a technology program.

A visit to the school site in its initial year revealed a well-devised technology plan at work. The Loara DHS Project made its objective a reality: to utilize every computer (not just to "place" a computer in every classroom). Loara reached this objective by installing computers in places where teachers and students would most likely use them.

This case study proves that strategic planning and sufficient funding play important roles in the success of a technology project. It also suggests that strong leadership, from an administrative level, is crucial to obtain the necessary commitment

from the school community, to keep the technology project on-track, and to successfully integrate technology into the curriculum.

Finally, for schools in the beginning stages of incorporating technology into the curriculum, this case study suggests that it is unnecessary (and a waste of time) to start from scratch. The old phrase, "don't reinvent the wheel" (so popular among educators), certainly applies to educational technology. Take advantage of the "first generation" schools (especially DHS Grant recipients) that have successfully implemented technology projects. Although every school will ultimately develop its own technology objectives, analyzing existing technology programs is beneficial.

Appendix 3: New Haven Unified School District

Overview of District

Demographics: The New Haven Unified School District is located in the San Francisco Bay Area and includes the communities of Union City and south Hayward. The school district's 11 schools serve over 13,800 students. There are six elementary schools (grades K-4) and three middle schools (grades 5-8). The main high school, James Logan High School, has approximately 4,000 students. El Rancho Verde High School is an alternative high school with approximately 240 students. The school district's student population is 27% Latino, 26% White, 17% Filipino, 16% Asian, 12% Black, 1% Pacific Islander, and less than 1% American Indian. 20% of the students are currently identified as Limited English Proficient or Non English Proficient. The school district's operating budget (1998-1999) was approximately $75 million; roughly $1.5 million went to technology.

Overview of Technology Environment: The school district has one of the most comprehensive school technology infrastructures in the State, including multimedia labs, video links between classrooms, projection equipment for computers, and administrative software that allows attendance to be recorded on-line. The school district's network supports both Macintosh and Windows platforms. On-line calendars allow faculty and administrators to consult their schedules to plan meetings. One computer entry creates an e-mail account, library card, and dining facilities entry for new students. The school district has a computerized circulation, catalog, and processing and inventory system for its multimedia materials. An on-line catalog shows location and availability of all instructional materials.

James Logan High School has approximately 2000 computers for 4,000 students. Each classroom has a minimum of six student workstations, one teacher computer, and one laser printer. In addition, there are two multimedia labs with 30 workstations in each. Elementary and middle schools have (at least) the minimum district ratio (1:5) of computers to students. Although classroom computer access was originally intended to replace the need for computer labs, the district has chosen to maintain a computer lab at

each site, with two labs per school in the middle schools and at the main high school. The school district is in the process of loading core software at each site:

K-4 Software

- Kid Pix Studio Deluxe
- JumpStart Kindergarten - Kindergarten
- Oregon Trial - 4th Grade

5-8 Software

- Amazing Writing Machine - 5th grade
- Math Blaster I: In Search of Spot - 5th grade
- Math Munchers Deluxe - 6th grade
- The Incredible Machine - 6th grade
- Schoolhouse Rock: Grammar Rock - 6th grade
- Castle Explorer - 7th grade
- Rainforest Researchers - 8th grade
- A.D.A.M. the Inside Story - 8th grade

9-12 Software

- In My Own Voice, Language Arts
- Favorite Greek Myths, Language Arts
- The Environment, Science
- Immigration, Social Science
- On the Campaign Trail, Social Science
- Timeliner, Social Science

In addition, each school has a library server/CD-ROM tower that loads various references and other sources. Although, this varies among schools, all have the World Book Encyclopedia. Individual sites may supplement the core software if they choose.

Technology Planning and Funding

Vision and Initiative: The vision for the school district's technology plan originated from a former New Haven Superintendent. A former teacher, he believed strongly in using technology for school administration and bringing technology into the classroom.

Technology Planning Process: The first technology plan was adopted by the school board in July, 1986. This plan was updated in 1994 to integrate classroom uses of technology and administrative uses; it is currently due for a third revision.

In 1993, the school district contracted Hewlett Packard (HP) at a cost of $100,000 to perform a technology needs assessment. HP designed a three-part analysis. First, they solicited input from the entire school community, surveying and interviewing teachers, administrators, parents and local leaders. The second part of the analysis was a logistical design phase; HP proposed alternative hardware and software designs to meet the needs defined in stage one. The costs of the models they developed were estimated by first overlaying the model on one school and then extrapolating up for the number and comparative size of the schools in the school district. Once these first two phases of the planning process were completed, the school district felt it had developed enough technical knowledge to complete the final physical design phase internally.

Funding:

Funding for implementation of the New Haven Unified School District technology program has come from four primary sources: general obligation bonds, developer's fees, the Union City Redevelopment Agency, and the school district's general fund.

Initial funding: Money for the initial infrastructure and capital costs came from general obligation bonds. The New Haven Unified School District has succeeded in having three bond initiatives passed in the last 15 years. The initial network, wiring, and infrastructure for the school district was funded by a $55 million bond measure for school technology approved in 1993, half of it was designated for technology.

Ongoing funding: Maintaining the school district's technology program is expensive. The school district estimates that annual technology expenditures increased

$800,000-$1,000,000 from four years ago. Money for technology maintenance and management comes out of the school district's general fund. This fund is augmented by funds received through an agreement with the Union City Redevelopment Agency. This agreement, negotiated in the late 1980s, was designed to reimburse the school district for the tax revenues lost from the formation of a redevelopment zone within the school district. The New Haven District will receive a total of $7 million through this agreement. Developers pay the standard $1.96 per square foot for residential development plus an additional $1.50 for permits. Over the last two years, the general fund has received $400,000 annually from developer's fees. This money is unrestricted, but has been budgeted by the school district to compensate for increased technology costs.

Replacement Funding: Funding for replacement costs should come from the agreement negotiated with the Redevelopment Agency. Starting in 2001, the Redevelopment Agency will pay off the remaining $5,400,000 of their obligation to the school district at a rate of $1 million per year through 2006-2007. Although this money is earmarked to upgrade the current technology system, it may not be sufficient. In addition, there may be other needs that take precedence over the technology program at that time. The school district anticipates that more state and federal technology funding will be available; otherwise, technology spending will have to be reduced or money will have to be shifted from other school expenditures.

Other: Funding is also drawn from other sources in a more piecemeal fashion. In 1993, Logan High received $103,000 for technology in state funds under Senate bill 1510. The school district received $240,000 for an initial 18-month period for telecommunications charges under the federal E-rate grant.

Budgeting:

Initial expenses: The school district estimates that it spent over $35 million on equipment and building modifications to support its technology program. The $27 million in designated technology bond money paid for the network and wiring of the 11 schools that were in the school district in 1993. With the addition of an elementary school, the school has spent approximately $35 million on its technology infrastructure.

Because bond money can only be used for infrastructure, not the purchase of hardware, money had to be moved around. The approximate breakdown of initial costs is displayed in Table 1.

Table 1. Breakdown of Initial Expenditures for New Haven's Technology Program

ITEM	DOLLARS SPENT
Computers and printers	8 million
Electrical upgrades	3.1 million
Video distribution	3 million
Wide area network	2 million
Telephone upgrades	1 million
Document management systems	1 million
Local area networks	10 million
Total	28.1 million

The school district spent $100,000 on the needs-assessment performed by Hewlett Packard. Of the state money Logan High received in 1993, half of the funds went to hardware and software, the other half was used for training, release days, and paid summer technology curriculum development.

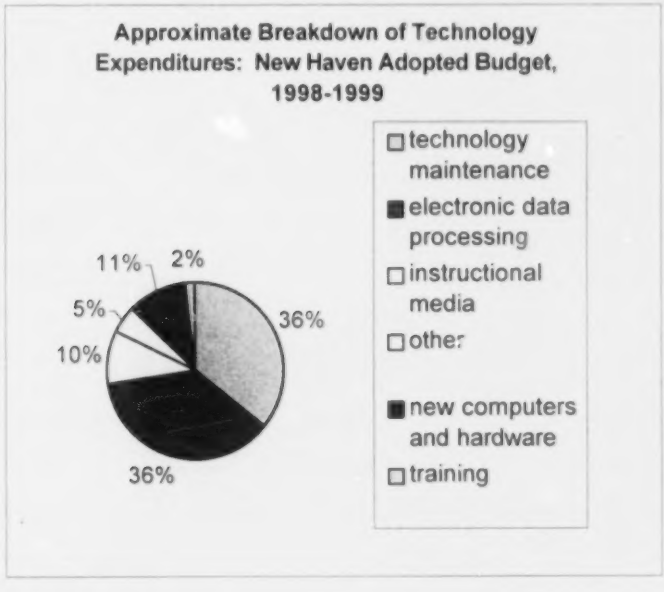
Ongoing costs: Hardware, software, maintenance, and professional development costs come out of the general fund or from outside sources. Table 2 shows the amount budgeted for each technology area in the 1998-1999 budget adopted in June, 1998. Approximately half of the school district's annual technology expenditures are for personnel costs, the rest is for equipment and hardware purchases.

Table 2. New Haven Unified School District Technology Budget, 1998-1999

	Personnel	Equipment and supplies	Total
Maintenance	$380,014	$259,000	$639,014
Electronic data processing	$523,233	$130,294	$653,527
Instructional media (~20% of the IM budget goes to technology, in the form of software enhancements)	$753,133	$108,414	($861,547*.2) = $172,309
Other	$1,601	$87,489	$89,090
Training	$30,000		$30,000

New hardware		$200,000	$200,000
Total technology budget			$1,553,940

The proportion of funds spent on each program area is illustrated in the pie chart below. Technology maintenance and new computers and hardware make up the largest proportion of the technology budget, at 36% each. There is relatively little money allocated for training, although the 2% explicitly spent on training does not capture teacher collaboration time or the salaries of the technology coordinator and teachers who are the primary means of integrating technology into the classroom.



Contracts and Purchasing:

Contractors: Because the school district is required to contract the lowest bidder, comprehensive design and performance specifications were crucial to ensure that the work was completed satisfactorily. The school district hired a network architect to design their wide area network.

Computers: Apple computers must be purchased directly from the company, and the school district purchases PC's through the California Educational Computer Consortium. In both cases, machines come with a one-year warranty.

Parts and software: All technology hardware and software purchases must be approved by the technology department to ensure network and hardware compatibility.

The department only orders hardware and network parts, and does not perform content or curriculum evaluation for technology purchases.

Management of Technology

Installation and Implementation: The technology plan was implemented in stages, three schools at a time. Contractors did the wiring and infrastructure improvements. The hardware was installed in classrooms by the school district's technology technicians.

Ongoing Maintenance: The school district's technical staff repairs technology items, and is then reimbursed for the repairs still under warranty. Technical problems are reported on-line. Each staff computer has a bookmark that brings up a report form. These reports are submitted to a central location for each site and prioritized by an administrator, usually the assistant principal. The school district has six technology technicians who provide on-site technology support. Each technician is responsible for two schools (usually one elementary school and one middle school), and alternates days at each site. The high school has two full time technicians. Problems can be escalated up to a technology specialist in any of the school district's three technology areas: hardware, video, and networks. In addition, the school district's technology coordinator convenes a monthly meeting of technology facilitators to discuss technology uses and problems.

Table 3. New Haven Unified School District, Technology Position Salaries and Qualifications

Title	Salary Range	Qualifications
Technology-Information Systems Director	$53,000-$61,000	
Technology Coordinator	$45,000-$53,000	1. Media Specialist Credential. 2. Five (5) years of teaching/media experience. 3. Experience with computers and other technologies. 4. Administrative Credential
Senior Programmer/Analyst	$34,000-$42,000	1. BS in computer science or equivalent. 2. Minimum 5 years of programming on an HP3000 computer using COBOL, IMAGE, VIEW, and QUERY. 3. Minimum 3 years programming experience in

		personnel administrative software.
Senior Network Specialist	$34,000-$42,000	1. Certified Novell Engineer (CNE) with 4.1 experience and training. 2. Apple Share administration experience. 3. Experience in supporting Windows and Macintosh clients. 4. Three years experience in an electronic network environment. 5. Excellent written and verbal communication skills.
Computer Operation Specialist	$35,000	1. Two years experience in HP 3000 computer operations.
Lead Technology Technician	$35,000	1. Experience and knowledge of microcomputers, word- processing software, computer repair, network administration. 2. Experience coordinating a computer repair facility. 3. Completion of Apple maintenance self-service exam.
Technology Technician	$29,000	1. Hands-on experience and knowledge of microcomputers, word-processing software, programming and video equipment.
Technology Trainer	$35,000	1. Prior teaching, training or support experience in computer software. 2. AA in technology, or equivalent.

Security: The school district has both physical security considerations (that is, the risk of hardware being stolen), and network security concerns. The school district has cables and locks to secure each monitor, CPU, VCR, and LVD player to a table. In addition, the school district uses software and firewalls to separate students from administrative and instructional files.

Professional Development: Courses in the use of administrative software (word processing) are offered at the school district's main office. The school district also uses a "train the trainers" model for teacher training. Each school has a teacher who serves as the technology integration facilitator for his or her site. These facilitators attend monthly training sessions with the school district's technology coordinator and then conduct training sessions at their schools during teacher collaboration time.

Upgrade and Discard: Many of the school district's original computers are aging. The school district has a seven-year replacement cycle, so the first round of replacements will begin in 2000-2001 school year. In order to keep older hardware compatible with current software, the school district upgraded to a minimum of 24 MB of memory on all computers, although most of the district's computers have 32 MB. Individual schools can make additional upgrades or purchase more powerful computers at their own expense prior to replacement. Classrooms can keep older computers if they have other uses for them. Computers are sold to vendors after this time.

Unanticipated Costs and Difficulties

Even with New Haven's comprehensive planning, a few areas have been problematic. Funding the ongoing costs has required infusions of additional money from outside the general fund that the school district negotiated through special developer's fees. Funding replacement technology has also required the school district to find outside money (that is, through an agreement with the Redevelopment Agency). Even with this arrangement, the school district can only afford a seven-year replacement cycle, two years longer than the five-year cycle recommended for schools. In addition, both the developer's fees and Redevelopment Agency funds will end by 2007 (at the latest), and it is not clear how the school district will maintain its investment after that time.

Firewalls and other designs to keep the network properly managed have required some rethinking as the technology plan has been implemented, although these costs have not been higher than originally estimated. Initially all workstations in the high school allowed unrestricted access to the Internet, and teachers were responsible for monitoring students' use for appropriateness. This system proved unrealistic for after-school programs, and student use of the Internet is now restricted through a proxy server that screens for hate speech, gambling, gaming, dating, sex, criminal skills, and extreme or obscene sites.

Another area that has required revised design is back-up systems. When the network was first implemented, individual sites were responsible for backing up servers. With 100 servers in the school district today, a more centralized data protection strategy was needed to ensure that data is not lost when a server crashes. In addition, ergonomic

concerns are likely to be the next issue the school district addresses. When the technology plan was initially implemented in mid-1990s, the school district made sure that all the furniture was adjustable but has not addressed ergonomic concerns in a more systematic way.

Finally, ensuring that technology is fully utilized is a difficult goal to reach. Many teachers were reluctant to use the technology during the initial years because the network was unstable and has only become reliable in the last year. Although the school district has integrated most ongoing costs of technology into their budget, staff training remains a difficult area to fund. The school district offers training for teachers and administrators throughout the year, but available technology is still not being utilized fully in every classroom, partly because not enough money exists to train all the teachers. The school district is committed to the "train the trainers model" for professional development, but because of other priorities, it can be difficult to ensure that on-site training occurs. During the first two years of the implementation of the technology plan, the school district received an instructional hour waiver from the State that allowed them to use Wednesday mornings for teacher technology training at elementary and middle schools. Logan High School has enough instructional minutes that a waiver was not required. This collaboration time was initially reserved for technology training. By ending collaboration time at the end of March, the school district now maintains enough instructional minutes without requiring a waiver. Without this waiver, the time is no longer reserved for technology training and other business tends to take precedence. At Logan High School, where the waiver was never required, technology training has dropped off as teachers master the basic functions of the technology and only the most enthusiastic persist for web page design classes and other more advanced training.

Summary: Analysis of Lessons

Technology planning takes a great deal of time and energy, and implementing the plan is expensive. New Haven has done it right – planned carefully, secured future funding – yet even this sophisticated, well-laid technology program may not be sustainable.

The New Haven Unified School District is a good model for centralized planning. The school district has undoubtedly saved time and headaches by ensuring compatibility through a centralized system. It is difficult to know whether contracting out some of their support services would reduce ongoing costs. New Haven has decided (as soon as it felt it had enough internal expertise) to implement and support its own technology program. Centralized technology planning does reduce training time and costs as staff and teachers use the same software when they move between sites. This is particularly important because professional development remains a crucial (but difficult) area to fund.

The administrators with whom I spoke stressed the need for technology to be planned at the school district level because teachers and administrators at the schools do not have time to plan out networks. Centralized planning for technology ensures compatibility between systems and allows computers to be used for school district-wide data and information storage. One technology specialist recommended that the State provide "canned" technology plans for school districts to use as models. California has already made efforts to provide this kind of assistance, but information and expertise may not be reaching the schools and the school districts that request it.

Appendix 4: Inner City Elementary School

Overview of District

Size, Location, and Demographics: This inner city elementary school (grades K-5, ~440 students) is located in San Francisco. The school was designated as a computer focused school following a segregation lawsuit ending in 1984. The Consent Decree ending this lawsuit requires the federal government to infuse substantial funds, earmarked for technology and other specified purposes, into the school through 2002. The school is majority African American, with smaller populations of Latinos, Cambodians, and Samoans. The technology teacher estimates that few students have computers at home – perhaps only five in 440. 73% of the students participate in the free lunch program.

Overview of Technology Environment: The school was an early adopter of technology, especially for an elementary school. In the early 1980's, it had a Computer Curriculum Corporation Lab (terminals used for drill and practice exercises). Following the lawsuit, the school district put in a lab of networked Apple IIEs. These were removed in 1996 when the school secured a large donation of PCs from Pacific Bell (through an intermediary, Detwiler Foundation). Currently the school has one fully furnished computer lab and approximately four PCs in each classroom. At the time of the donation, the PCs were unused, upgradeable PCs equipped with donated Intel chips and motherboards. They have since been upgraded with new motherboards, sound cards, more RAM, and fans. All the computers run over a Windows NT network. Internet access is furnished through a 56K Frame Relay connection to School District intranet, which in turn connects to the Internet over a T-1 line. Following an office move within the school district, access to the Internet will be over a T-3 line. In terms of peripherals, the school has 31 printers and a headset for every computer. A backup system is also in place.

The principal applications used at the school are:

- Word, Excel, and Netscape.
- Educational CD-ROMs.

- McAfee Virus Scan.
- Cyberpatrol (Internet security, employed at the District level and also loaded onto each computer).
- CD Quickshare (allows sharing of CDs from a CD server).
- Mirror (network administration software that allows the network administrator to rebuild a computer without having to manually reload all of the applications).

Technology Planning and Funding

Source of Vision and Initiative for Technology: The court system, with the school district's consent, imposed the adoption of technology at the school. The school's 1998-1999 School Accountability Report Card states: "[o]ur school is designated by the Consent Decree as a computer focused school which enhances learning, knowledge, problem solving, and creativity through the use of technology." In 1987, two school district technology experts working with the Consent Decree schools wrote a detailed technology mission statement and plan. The plan stressed: 1) equal access to computers; 2) creative use of computers (that is, they should not be used like flash cards); 3) incorporation of technology into schools' education and management objectives. While the plan was written for all Consent Decree schools, it had particular importance for this school. One of the authors went on to become the principal at the school for nine years. The other is still involved in the technology program, and has asserted his vision on several occasions. Hence, this plan has come to life at the school. The current principal wholeheartedly supports the technology program. The school is focusing on using technology to achieve its number one educational objective: improving achievement in reading.

In addition to sharing the vision of the technology program, the technology teacher sets the tone on a day-to-day basis. She is responsible for shaping how the teachers use technology. She believes students should be using and learning the same tools found in the "real" world; hence, the school uses Word, Excel, and Netscape. In addition, she believes computers should be a supplement to lesson plans, not a lesson in and of themselves. She spends much of her time helping teachers integrate computers and the Internet into lesson plans.

Technology Planning Process: The 1987 school district technology plan is still the guiding statement of the school's technology program. The school does not have a specific plan for its program.

The school district has been very active in decisions regarding hardware, the network, and technical support. The school district staff and the school's technology teacher exchange ideas on a regular basis. The school district staff has made the actual purchasing decisions for the network architecture, and the technology teacher has purchased hardware (headsets and component parts) and software.

During the recent refurbishment of the school facilities, including the installation of the wiring and network equipment, the technology teacher and the school district network expert were actively involved with the architects and contractors, and essentially laid out the project's specifications. There was no school-wide or community-wide planning process.

Ad hoc planning takes place when the technology teacher recognizes a need for software. She often will test the product, and then consult with teachers who would use it and decide whether to get it.

Funding: The school district receives roughly $37 million / year in federal funding earmarked for Consent Decree schools. This funding is distributed to the appropriate schools. This school received about $500,000 in 1998 for technology and other Consent Decree programs (for example, outdoor education). The principal has some discretion how to spend this money, and most goes to teachers' salaries since a primary purpose of the funds is to increase the teacher to student ratio. The remainder of the funding is allocated to technology training for teachers.

The major capital investments have been made with one-time funding sources. By passing Proposition A, San Francisco voters approved major capital expenditures for school refurbishment, including the installation of wiring and electrical upgrades for computer networking. The school completed a major refurbishment in 1996 with Proposition A funds, and the building was retrofitted for the computer network and lab. The PCs came from Pacific Bell through the Detwiler Foundation, one of the state-supported programs for recycling computers. The school bought headphones, a file

server, router and hubs, memory upgrades, and sound cards with money donated by MCI. MCI helped wire four classrooms at the school during the original Net Day.

Budgeting: There is no budgeting for technology other than the technology teacher's salary and benefits. All software and hardware purchases come from a general account.

Contracts and Purchasing: The technology teacher will buy software either through the school district, which gets volume discounts, or from vendors directly. She picks the route yielding the best deal for the school.

The school district is the major buyer, or at least coordinator for purchases, for most equipment. It receives discounts on software and hardware that it passes on to individual schools. The school district also shops around for recycled computers. It frequently gets monitors for free.

For major technology projects involving the installation of wiring and electrical upgrades, the jobs are handed over to the facilities department. This department bids out the work to contractors; numerous regulations govern these bids.

Management of Technology

Installation and Implementation: An outside contractor completed the major installation of the NT network at the school. The school district expert in networking ended up getting involved, and had to oversee much of the work being done by architects and engineers who had presented themselves as experts in this area. The technology teacher was also a hands-on contributor to this process.

Ongoing Maintenance: Several individuals at the school district "look out" for the school and make sure the school's technology program continues to function. The technology teacher is the in-house resource for monitoring the equipment. Basically, teachers will report problems to her. She handles most application problems and inquiries. For technical hardware problems, she will take a brief look at the problem if possible and then forward it to the school district. One school district employee, who previously had been a contractor for the school providing technical support, spends about 10-12 hours / week at the school. Many problems are brought to his attention on an

informal basis when he is there. There is a formal process for reporting problems that involves submitting a "blue form" on the school district's web site. All network problems are reported this way. The forms are required to get school district support.

The school district is moving to a model of centralized support. The idea is to apply the current model of school maintenance to technical support. With facilities maintenance, the required personnel (electrician, painter, plumber, etc.) visit the site in a team and do the jobs at once. The school district would assign support teams to different areas of the district and literally put them in trucks to visit sites. The school district is also working on a more robust system for reporting and tracking problems, and has been evaluating help desk software. The school district has hired a consultant to reorganize its technology operations.

Professional Development: The school has had a long history with professional development in using technology in education. As mentioned above, the school receives steady funding for this purpose as a result of the Consent Decree. Each teacher has to complete ten hours / year of in-service training on technology. The technology teacher is responsible for the training, and leads the training, which consist of small groups of teachers with common needs and interests. In addition to the ten hours of in-service staff training, teachers can go to classes coordinated by the school district at San Francisco State Exploratorium. It also focuses on integrating technology into the curriculum. Last summer, the program paid teachers to attend.

Upgrade and Discard: The school district and the school have taken a fairly minimalist approach to upgrading and/or discarding computers. If the computers still serve an educational purpose, they are used. Upgrades to the PCs have been fairly standard and were dictated by technical requirements. The school has not had to deal with problems with discarding computers. The school district moved its old Apple IIEs to another school.

Unanticipated Costs and Difficulties

No one involved with the school's technology program would say if they had unanticipated costs and difficulties. But to an outsider, the school appears to have a very experienced group of professionals. The school district employees who have kept a

watchful eye on the school have been involved in setting up numerous labs and networks in schools. The technology teacher has been in her position since 1986. But, like all other technology programs, they encounter numerous unanticipated costs and difficulties.

One big unanticipated obstacle in the school's technology program was the Pacific Bell donation through the Detwiler Foundation. The school district lost time and money in the machines, both to equip them for use in the school, and to support them. For example, the machines came with 133 MHz processors and motherboards designed for 90 MHz processors. As a result, the school installed new motherboards to realize the computers' true performance capability. In addition, the other components in these computers were "not what a technician would recommend."

A second big unanticipated obstacle was the installation of the network. The subcontractors sold themselves as experts in network design and installation, but proved to be less than experts in the minds of the school district and the technology teacher. The school district network expert and the technology teacher had to become very involved in overseeing all subcontractors' work to ensure that the school was getting what it wanted. As a result, several designs had to be re-examined and "change orders" on these types of contracts were costly. The school had problems down to the length of the tables, the placement of cords, and the window blinds, in addition to problems like where to place the router and hubs. The hubs were ultimately placed in a storage room in the basement, an inconvenient location that did not seem to be justified by any engineering criteria.

A third unanticipated source of costs has been the sheer pace of change in technology. For example, the rapid growth of the Internet and its usefulness in school settings necessitated more memory, new software, and more attention to the appropriateness of some Internet content. Presently, change is particularly rapid in the area of networking. Now that the school's technology program runs over a Window NT network, the school is particularly reliant on the school district's network and support.

Summary: Analysis of Lessons

What is happening right in the school? The school has a large number of networked recycled computers up and running and being used by students daily. The technology team, composed of school district staff and the technology teacher, is highly

committed to technology to the extent that it improves education. The school is committed to helping teachers integrate technology in the curriculum. The school has a full time technology teacher who focuses on working technology into lesson plans; each teacher does ten hours / year in-service training on using technology in education; and the school district has coordinated additional learning opportunities for teachers. The school seems to get adequate technical support, thanks to a school district particularly attentive to the school. The school will likely continue to be a leading technology user among elementary schools because of the Consent Decree making it a technology school.

What are the key ingredients in the school's technology program? First, the school has a point person for its technology program. The technology teacher has great commitment to, and responsibility for, the technology program. She is in a position to make things happen. Second, the school has a very strong relationship with the school district. It receives unusually responsive and expert advice and support from the school district staff. Third, the school has consistent funding for technology. Federal support for the school's technology is built-in, long-term budgeting for technology. Although the school does not actually budget for technology, the yearly infusion of federal funds into its general accounts covers the ongoing costs of the program. Finally, and perhaps most importantly, the program has support from the teachers. This is partly due to the leadership of the Principal and the technology teacher, but primarily due to the fact that the school is a designated technology school and teachers coming to work for the school choose to incorporate technology into their classroom.

These key ingredients translate into useful principles for other schools adopting technology:

A technology program needs to account for its ongoing costs. The school spent relatively little on the actual computers in the lab and classrooms. In fact, they were supposed to be "free." The school district put a lot of time into upgrading component parts, but the total initial cost for each computer presumably ran far below retail levels. Where the cost of the school's technology program starts to add up is with the ongoing costs for training and support. Ten paid hours of training for each teacher adds up. Then, there is the full-time technology teacher; the school district employee who is always

thinking about the school's program and the uses of technology in education; the school district technical support person who puts in 10-12 hours / week working on various problems; and the school district network support person who keeps the network running.

People matter. A technology program is more about the people running it than the technical architecture. The technology teacher at the school put it best: "I could not do it alone." Schools adopting technology need to have leadership in technology from the principal, a dedicated point person for running the program, and support from the teachers.

Since people matter, they need training. Teachers at the school are required by the Consent Decree to complete in-service training on technology. Each teacher spending ten hours in small groups with the technology teacher goes a long way to ensuring that technology is used in lesson plans and that teachers continue to support the program.

In terms of lessons for other schools, the school's technology program offers very little in the terms of specific processes or practices. One specific best practice that could be gleaned from the school's experience is writing a very detailed RFP for installation contracts and having a network designer examine the school site plans before the bid goes out. With regard to other aspects of owning a technology program (purchasing, technical support, and ongoing assessment), the school has workable, ad hoc solutions. Their solutions do not stand out as models for other schools.

Finally, the case study raises a question pertinent to all schools. Is the technology program sustainable? Where will the money come from when the federal funding (other schools obviously have different funding sources) dries up in 2002? Will the school find more money, decide to cut back other programs to fund the technology program, or cut back the technology program? A second concern is losing one of the key members in the technology team. Certain individuals have scrambled to keep the program functioning. Who would pick up the slack if this team were dismantled for some reason? The school could not do it alone. With a sophisticated network of computers, the school needs technical assistance whether it comes from the school district or a private firm.

Implementing and maintaining a sophisticated technology program is too big a task for a small middle school with a plethora of pressing problems besides computers.

In this case, it is not clear that the technology program will be sustainable in its current form when federal funding ceases. Given the current state of policy regarding technology in K-12 schools, the school will have to find a new source of funding for its program. The school will need to apply for, and obtain, grants from the federal government, private corporations, and foundations. The program will need a new "marketing" dimension to compete on this grant circuit.

Appendix 5: Broadway Senior High School

Overview of District

Size, Location, and Demographics: Broadway Senior High School (BHS) is a continuation school, located within the San Jose Unified School District, the largest district in Northern California. The enrollment at BHS is very fluid, as students are sent to continuation schools when they: 1) exhibit discipline problems; 2) are in transition between regular high school and the juvenile justice system; 3) are over the age of 18, yet lack the necessary requirements to obtain a high school diploma. Students attending BHS will be there between six weeks to two years. Currently, the school has an enrollment of 344 students, including 60 teen-age mothers (ages 14-17). The two largest ethnic groups at BHS are Hispanics (69%) and Caucasians (24%).

Overview of Technology Environment:

Table 1. Computer Labs at BS

Lab Name	Computers	Accessories	Cost	Purpose
Multi-media and Graphics lab	8 Apple Macintosh Power G3, 4 equipped in 25 inch monitors, 6 Apple Macintosh II and Quadra.	One wax printer, two laser printers, two scanners, and one projector. All computers are connector to a Local Area Network (LAN) and AppleTalk	Computers were purchased at different times, with costs ranging from $3,500 to $5,000. Printers and Scanner total: $14,000	The primary purpose of this lab is to instruct students in computer graphics and multi-media software, modeled after a certificate program at vocational schools.
Distant Learning Lab	21 Apple iMac, Apple OX Server	2 Apple laser printers. All computers are connected through a new T1 connection	$71,000 (San Jose District $20,000 + $51,000 donation from NovaNet)	The primary purpose of this lab is for use by several classrooms to connect to a distant learning program operated through the University of Illinois-Urbana. Students are allowed to go through a variety of self-paced educational software. Students with limited English Proficiency also use the lab for their language skills.
Math Classroom	14 Apple Macintosh SE	One LCD overhead projector, one HP scanner. All computers are connector to a Local Area Network (LAN) and AppleTalk	No data on cost. Teachers donated scanner	Mathematics instructors use this classroom at various time during the year.

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BHS also has a separate Robotics labs, with computers donated through a program operated by NASA Ames Research Center in Mountain View.

Technology Planning and Funding

Source of Vision and Initiative for Technology: Although the San Jose Unified School District adopted a plan in 1995, BHS was neither consulted nor required to conform to the school district's requirements due to its designation as an alternative school. Therefore, between 1995 and 1997, BHS only received supplemental computers and equipment from other schools: overhead projector (1), television and VCR (1), Apple Macintosh IIe (3), and Apple Macintosh SE (2). In 1997, a new principal arrived at BHS from a vocational school. The new principal brought a specialist from the vocational school and installed her as the new Computer Lab Director.

There are five primary goals stated within the BHS technology plan:

1. Effective utilization of technology as a valuable asset in the school's instructional program. Pilot programs in Spanish, Science, and Mathematics have been established for 1998-1999.
2. Assist in providing effective management of the school site.
3. Development of student technology skills.
4. Internet technology available in every classroom.
5. Assist Limited English Proficiency (LEP) students with language development skills.

BHS has developed three sets of standards for implementing these goals:

- *Student Technology Use Standards*: Indicates goals for comprehension of computer operations by students. These operations are defined as hardware, software, social and legal aspects of technology, and "nature of technological design."
- *Teacher Technology Use Standards*: Identify how teachers should use technology as part of the curriculum planning and instructional development. It also indicates the need for computer proficiency and commitment by the teachers.

- *Administrator and Staff Technology Use Standards*: Outlines steps that administrators and staff can use to improve the management and daily operations of BHS. It also requires proficiency and commitment by administrators.

The plan outlines the infrastructure and software standards adopted by the school outlined management issues relating to the adoption of technology standards.

Technology Planning Process: The Computer Lab Director created a team of BHS teachers, students, and outside advisory to create a five-year plan. This volunteer group composed of a lawyer, a retired principal, a graphics company representative, a computer programmer, and technical support personnel. Other programs (for example, the K.I.S.S. Robotics Lab and the Vocational Math Program) required an industry or community advisory group. It appears that much of the work of this advisory group has been perfunctory. Since the school district had an adopted plan, they participated in the process. The plan is revisited twice a year for modifications.

Funding: Since a large percentage of students at BHS are classified as Limited English Proficient, one of the primary goals of the school was to utilize computers to assist these students. BHS applied for special funds targeted for Limited English/Non-English Proficient students through the state Department of Education. BHS received these funds from 1997 through 1999. However, these funds are not guaranteed and BHS needs to apply every year to receive them. BHS has spent the funds to address short-term needs (for example, new printers and electrical wiring). The Math lab was funded though a satellite program with the Vocational school.

NovaNet, a private on-line education company provided computers to the distance learning computer lab. The school has the right to use the computers, but is required to pay $20,000 in five years for the computers. NovaNet estimates that the actual cost to them for the computers is $51,000. However, BHS needs to go through the NovaNet web site to access distance learning programs. NovaNet is also in the process of developing on-line educational materials. It is not apparent whether they view BHS as a potential customer in the future or whether BHS agreed to test their educational software.

BHS also received a number of grants from local area business and philanthropic organizations. One of the primary tasks of the technology coordinator is to search and apply for

such grants. These grants were used to supply what the school needed to complete the other projects listed above. These needs included a new scanner to accompany new multi-media equipment the school had purchased. These funds totaled $23,000 in 1997 and $15,000 in 1998.

Budgeting: Most of the funding obtained by BHS has involved a number of one-time donations and/or grants. Therefore, it is not surprising that BHS has not separated the costs of its technology programs into a separate category in the school budget. In addition, since BHS is designated as an alternative school, it is not eligible for most long-term funding from the State. BHS has attempted to purchase computers according to its adopted Technology Plan. With the absence of multi-year funding sources, technology related items are not itemized in the school budget.

Management of Technology

Installation and Implementation: Since most of the funding obtained by BHS was through one-time grants and/or donations, the installation of equipment obtained through funds immediately followed the receipt of dollars. When BHS applied for funds, it had to identify how it would use the dollars to implement its goals. BHS relied upon its own teachers and students to install the new equipment. BHS re-wired all the computer labs and established Local Area Networks. It used these installations to educate other faculty members and students. BHS believes that by doing most of the work itself, it can save money on support costs in the future.

Ongoing Maintenance: BHS relied primarily on its faculty for technical support and maintenance. Items that can not be dealt with are referred to the school district. The response rate depends on who calls and the ability of the caller to identify the problem. Some teachers who have received advanced training are called upon to provide assistance to other faculty members. The technical coordinator provides the majority of technical support needs in both the Distance Learning and the Multi-media Labs.

Professional Development: The principal requires that all teachers receive training before computers are installed in classrooms. Training includes:

1. *Level I*: Basic computer operations. (Minimum requirement for all teachers working with computers).
2. *Level II*: Writing educational curriculum using computers.

3. *Level III*: Technical training for maintenance of computers. (Teachers with this level of training are also required to provide support to other teachers.)

BHS relies on two primary sources for staff training. First, the school district provides a one-week training course. BHS has sent five teachers and two administrators to these courses. Second, as a condition of receiving donated computers for their new Distance Learning Lab, NovaNet provided training for five teachers. It should be noted here that the technology coordinator, the head of the Robotics Lab, and several other teachers at BHS had substantial amounts of training before joining the school. The school has relied on informal educational processes among staff.

Upgrade and Discard: BHS has identified an optimal 20% replacement rate. This rate was derived on the basis of the different levels of student ability and need. At this rate, BHS has enough new computers to take advantage of the latest educational technology programs, while providing adequate computers for students still learning the basics. BHS also uses a number of older computers for a hardware training program for students. Newer computers and printers are installed in computer labs, while older ones are re-assigned into separate classrooms. The schools had no data available on discarding since the school district assumes these costs.

Unanticipated Costs and Difficulties

The unanticipated costs are mostly related to the age and condition of their facilities. They can be broken into two major categories. First, the problem of electricity and wiring in rooms designated for computers labs. These rooms do not have enough outlets or wiring needed to provide electricity for computers, printers, and other auxiliary equipment. BHS was forced to completely re-wire three classrooms. Second, the school's heating system was operated through heated floors (hot water pipes). Therefore, BHS had to invest in tables and desks to raise the computers and other equipment above ground. Since the school had no air conditioning or ventilation system in these classroom, it had to install a new system.

Summary: Analysis of Lessons

Strong leadership and expertise from its technology coordinator are the main reasons for the success at BHS. The technology coordinator's background as a former Silicon Valley executive and teacher gives her the knowledge about procurement and implementation of

technology programs. She developed a comprehensive plan by assessing what the school had, what it needed, and how it could implement it. The inability to secure a sustainable long-term funding source further highlights her ability to obtain the dollars needed to implement a technology program. The support of the principal also allows her to do what is necessary.